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THE AMERICAN EDITION

OF THE NEW

EDINBURGH ENCYCLOPÆDIA.

MEDICINE.

Sect. XIX. *Variola. Small-Pox.*

WE now come to the second genus of the Pyrexiæ, the Exanthemata, diseases consisting of fever, upon which supervenes, at a certain period, a cutaneous eruption, characterzied by specific symptoms, and continued during a certain length of time; they have also the peculiar property of occurring once only during the life of the individual, and they appear to be always produced by a specific contagion. The diseases to which the above character strictly apply, are Variola, Vaccinia, Varicella, Scarlatina, and Rubeola.

The disease of Variola, or small-pox, which a century ago was scarcely less dreaded than the Plague itself, affords a memorable example of the triumph of the medical art over what appeared to be an inevitable evil attached to human existence. By the introduction of inoculation, the disease was rendered comparatively safe to the individual, and by the substitution of the vaccine for the variolous poison, this benefit has been extended to the community at large. Some time must be allowed for the prejudices of mankind to subside, but we have every reason to hope that ultimately this destructive scourge will be banished from all civilized countries. According to the degree of violence with which Variola exists, it constitutes two varieties, which, although evidently belonging to the same disease, and convertible into each other, differ essentially in their symptoms, and require different modes of treatment; from the peculiar appearances of the eruption, they have obtained the names of distinct and confluent.

The first invasion of small-pox is marked hy symptoms of general fever, which partakes of the inflammatory type, and is characterized by vomiting, and by pain upon pressing the region of the stomach. On the third or fourth day, the eruption begins to appear on the face, and in about two days is completed over the body. It appears in the form of small red points, which afterwards rise into pimples, and at length, by the fifth or sixth day, are converted into vesicles, containing a light yellow fluid. These vesicles are surrounded by an inflamed margin, so as to produce a considerable redness over the whole surface of the body, which is not actually occupied by the vesicles themselves; and all the soft parts, especially the face, is so much swelled, that the eyelids are often completely closed. About the eleventh day, the fluid in the pustules becomes opaque, and of a yellower colour, and being now fully matured, the vesicles burst and shrivel up, and the inflammation gradually subsides, leaving red marks upon the skin, which, when the disease has become violent, are succeeded by pits or depressions, that are never afterwards obliterated. The pustules on the other parts of the body proceed in the same order with those on the face, but go through their successive stages a day or two later, and are generally attended with less inflammation.

In the distinct and less violent form of the disease, the fever abates when the eruption is completed, and seldom returns in any considerable degree; but in the confluent variety, what is called the secondary fever comes on at the period of maturation, which is often equally violent, and is indeed more to be dreaded than the first, or the eruptive fever. All the symptoms are more urgent in this variety, and come on at an earlier period, although at the same distance of time from each other; the pustules are more numerous, so as to run into each other, and form large patches of continuous suppuration, while, at the same time, they are less elevated than in the distinct kind, and have less inflammation round their margin. The fever is also of a different nature, exhibiting more of the typhous type, and the system in general seems to be more oppressed and torpid, and to be less capable of reaction. The prognosis of the disease depends very much upon the nature of the variety to which it inclines; for while, in the distinct Small pox, we may generally hope for a favourable issue, the confluent is, for the most part, altogether beyond the reach of our remedies. What circumstance it is which produces the two varieties we know not: it depends, in a great degree, upon what may be called the prevailing character of the epidemic; in some the distinct, and in others the confluent, being much the most frequent; but we are not able to connect these differences in the nature of the epidemic with any external circumstances, or with any peculiar states of the constitution. We have sufficient evidence that it does not depend upon any specific difference in the nature of the contagious matter; because both the varieties are capable of being produced from the same source of infection.

Small-pox is always produced by its own specific contagion; and when once the individual has gone through the disease, in however slight a degree, he is secured from any future attack. Upon this fact is founded the practice of inoculation; for we learn, that where a portion of the matter is inserted under the cuticle, it will communicate a much milder disease than one that is received in the usual way, which is probably by the lungs. We are, however, totally unable to explain the cause of this difference. The relation which the fever bears to the eruption, or the degree in which one is to be regarded as the cause of the other, is a point that has given rise to much speculation. According to the humoral pathology, the eruption was thought to afford a remarkable example of the critical discharge of an offending matter from the system; and, proceeding upon this principle, the great object of the practitioner was supposed to be, to promote this discharge; a system which led to a practice precisely the reverse of the true one, and which must no doubt have proved highly destructive. In what way the fever operates, or what is the proximate cause of the disease, we know not; but it appears that the eruption is the consequence of the fever, and that, whatever diminishes the fever diminishes the eruption, and at the same time lessens the violence and danger of the disease. Our general plan of treatment is accordingly founded upon this principle, to diminish the febrile action of the earlier stages by the general application of the antiphlogistic plan, especially by purgatives and by external cold, and in some cases, where the inflammatory tendency is considerable, by blood-letting. In the distinct variety this may be regarded as comprehending the whole of the treatment; for it would appear, that all direct attempts to act upon the eruption, except so far as we can subdue the fever, are at least useless, if not positively injurious. Tonics and stimulants are seldom indicated, or only in consequence of some unusual occurrence; and when the disease has run through its course, the powers of the constitution soon return to their accustomed standard.

In the confluent Small-pox we have a much more formidable disease to combat, and one which, unfortunately, but too often baffles all our endeavours. From its very commencement it exhibits symptoms that have so much of the typhous appearance, as almost to deter us from the use of any active antiphlogistic treatment, and even purgatives and cool air appear to produce a dangerous shock to the oppressed and languid powers of life. Still, however, they afford the only rational means of relief; but they must be pursued with caution, and under the constant inspection of some person who is well qualified to judge of their effects. The circumstance which renders the practice, in this variety of the complaint, so critical, is, that when, from any cause, the eruption suddenly disappears—an effect which sometimes ensues from the sudden application of cold to the surface, or from the operation of a brisk purgative, the vital powers become suddenly oppressed in so great a degree, as to threaten the immediate extinction of life. When we suspect this to be the case, we are to apply external warmth, and to administer moderate doses of stimulants; but this is to be done with caution, lest in this way we exasperate the violence of the febrile action. Sometimes, without any obvious cause, this deficiency of action ensues, when we are immediately to have recourse to the same means with those mentioned above. When the symptoms of variola assume the decided typhous type, and especially in the secondary fever, it has been generally conceived that wine, bark, and other stimulants and tonics, are the appropriate remedies. We doubt how far this can be depended upon as a general mode of treatment; but we apprehend that we are, in these cases, to proceed very much upon the same plan which has been already recommended in the latter stages of other malignant fevers, of prescribing very much to obviate or palliate particular symptoms; bearing in mind, that we have to contend, on the one hand, with a tendency to febrile excitement, and, on the other, with the state of exhaustion, which generally succeeds the former, when it has been violent and long protracted. There is often, in confluent Small-pox, a state of restlessnes, or extreme agitation, which is found to be alleviated by opium; and although we do not expect any benefit to be derived from sudorifics, we conceive that gentle diaphoretics are often productive of great relief to the sensations, and, by removing a source of irritation, conspire with opiates in procuring sleep. One of the most distressing effects of confluent Small-pox, is the injury which it leaves to the constitution generally, or to particular organs, of which the eyes are the most apt to suffer, so as not unfrequently to produce the complete loss of sight.

Sect. XX. *Vaccinia. Cow-Pox.*

The singular affection of Vaccinia has become an object of great attention, in consequence of the remarkable property which it possesses, of protecting the constitution from the attacks of Variola; and as it is, under all its forms, a comparatively mild disease, and likewise possesses the peculiar advantage of being communicated only by absolute contact, it forms the means of securing the individual, without spreading any dangerous infection through the community at large.

The characteristics of Vaccinia are to produce a vesicle of a circular form, with a depression in the centre, which makes its appearance in three or four days after the insertion of the matter under the cuticle. On the eighth day it becomes filled with a transparent watery lymph; which, about the tenth or eleventh, is converted into a dark coloured scab, and falls off, leaving a permanent mark on the part. Although the constitution receives so important a change by the disease, yet the general febrile affection is almost too slight to be observable; and, except in some extraordinary cases, the only medical treatment which it requires is the exhibition of a purgative at its termination. It was not to be expected, that so great an innovation in practice should be generally received without opposition; but, whatever may have been the motives of the parties concerned, the results of all the controversies that have been carried on have been very fortunate; for we have, by their means, had an opportunity of viewing the subject under every possible form, so as to arrive at a degree of well-grounded confidence, which could not otherwise have been obtained. It is admitted, that there are cases where Small-pox has succeeded to Cow-pox; but they are of very rare occurrence; perhaps not more so than a second attack of Small-pox, of which a few unequivocal cases are upon record: and it has, moreover, appeared, that the Small-pox which follows Cow-pox, has had its virulence so mitigated, as to be nearly without danger. We may farther add, that the accounts which were, at one period, so industriously propagated, of loathsome eruptions succeeding to Cow-pox, are now considered to be altogether without foundation.

Varicella, or Chicken-pox, is a complaint which exhibits the characters of a true Exanthema, but is so mild in its symptoms as scarcely ever to become the subject of medical treatment; and is only worthy of our notice, as being sometimes confounded with slight cases of Small-pox, and thus given rise to the idea of a second attack of Variola, or of its occurrence after Vaccinia. Varicella may, however, be distinguished from Small-pox by the period of its successive stages, which are altogether much shorter, not exceeding, in the whole, five or six days, and in the nature of the fluid contained in the vesicles, which is watery and nearly transparent, never assuming the purulent appearance.

Sect. XXI. *Scarlatina. Scarlet Fever.*

Considerable difference of opinion has arisen on the subject of this disease, whether all the forms of it belong to one affection, of which they are merely varieties; whether the fever be symptomatic of the inflammation of the throat, or whether it more properly belongs to the Exanthemata, where the fever and the eruption are both essential parts of the disease. This latter we believe to be the correct view of the subject; and we farther conceive, that all the various forms which Scarlet fever assumes are simply varieties, like those which we noticed in Small-pox, principally depending upon its degree of virulence.

The disease consists of a fever, which usually inclines to the inflammatory type. About the fourth day the face becomes swelled, and large patches of a red efflorescence appear, which gradually spread over a considerable portion of the surface. These, in two or three days, terminate in an exfoliation of small branny scales; a degree of anasarca frequently supervenes, on the decline of the other symptoms. This may be considered as the simple form of the complaint, when it exists in a mild degree; but, in its more violent state, all the symptoms are aggravated. The fever, from the commencement, has more of the typhoid type; the redness is more considerable; and, at the same time, the deglutition and the respiration are affected, and an inflammation is observed in the internal fauces. These parts, when first affected, exhibit a deep red colour; they are quickly covered with a brownish fur; and vesicles appear, which assume a purulent aspect, and finally degenerate into gangrenous sloughs. Great general debility then comes on; and the patient is carried off in a few days, with all the symptoms of complete exhaustion, and an apparent tendency in the constituents of the body to fall into a state of decomposition.

The disease, when most acute, comes to its acmé in five or six days, and requires an equal period to pass through the remaining stages. When it terminates fatally, the event usually occurs from the sixth to the tenth day; but it not unfrequently happens that the patient survives long after this period, and is finally destroyed, as it appears, from the effects of mere weakness. It might appear highly improbable that so severe an affection as that of the throat should be only, as it were, an incidental part of the disease; yet this seems to be the case; for, in the same epidemic, we have some persons in whom the throat is severely affected, and others where it is not so, although, as was observed with respect to the two varieties of Small-pox, every epidemic has its characteristic form, or prevailing tendency, in which one variety is met with more frequently than the other.

We are quite unacquainted with the nature of the connexion which the different parts of the complaint bear to each other, but we have learned the important fact, that they all have an exact relation to the nature or degree of the fever; and hence we deduce the practical consequence, that whatever means tend to subdue the fever will mitigate all the subsequent symptoms. There is no complaint in which the cold affusion proves so valuable a remedy as in Scarlatina. The temperature of the body seems to be more increased in this complaint than in any other febrile affection; and we find that this method of applying cold not only effectually reduces the heat, but materially diminishes the virulence of the disease, so as, in a great measure, to ward off the danger which arises from its putrid tendency. If, however, these remedies fail in their desired effect, or if we have not had an opportunity of seeing the patient in the early period of the disease, we have unfortunately to struggle with a succession of symptoms, which it is commonly beyond our power to remove. Bark and wine were, at one time, regarded as essential to the cure; but, we apprehend, rather from theoretical opinions, than from any experience of their good effects. Emetics have been strongly recommended, as well as acids and acrid stimulants, together with topical remedies, such as have been supposed were adapted to subdue the tendency to putrefaction, or to counteract the effect of the putrid matter that was discharged from the ulcers. Some benefit appears to have been gained by the use of stimulating gargles; but, in general, we shall find the severe form of the scarlatina, when it arrives at its later stages, to be one of the most untractable and formidable of all complaints. Stimulants and excitants may be given, as affording the only prospect of relief; and all circumstances are to be carefully obviated, that may, in any way, exhaust the languid powers of the patient, or produce a degree of morbid excitement. As the disease is extremely contagious, the same means of prevention are to be resorted to, as we recommended above in other analogous cases; and we have reason to think that the acid fumigations possess the same power of extinguishing or decomposing the contagion of Scarlatina as of typhus. Some difference of opinion has arisen respecting the question, whether Scarlatina can occur twice in the same person? We believe that it cannot do so in any considerable degree; yet it would appear, that the same individual is subject to repeated attacks of a slight local affection of the throat, and even to a degree of fever, provided he is much about the person of the sick, or immediately exposed to the sources of infection.

Sect. XXII. *Rubeola. Measles.*

The only remaining affection of the proper exanthematous kind is the Measles, a disease which is characterized by a fever of the inflammatory type, together with all the symptoms of a violent catarrh, and particularly by a copious discharge of watery humour from the eyes and nose. About the fourth day an eruption of small red points makes its appearance all over the surface of the body, which, after continuing three or four days, disappears without proceeding to suppuration, and is succeeded by the desquamation of the cuticle, in the form of small branny scales; the fever and catarrhal affection disappear about the same period. A very remarkable circumstance in the history of medicine is, that Scarlatina and Rubeola were not properly distinguished from each other until about the commencement of the last century, a circumstance which has led some writers to suppose that Scarlatina is entirely a disease of modern times, and that it did not exist until just previous to that period, in which it was first noticed as a distinct affection from Rubeola; but, upon the whole, we do not see sufficient evidence for this opinion. The diagnosis between the two complaints, in mild cases, is perhaps not always very easy, nor is it very important; but whenever they are either of them severe, no difficulty occurs in the discrimination, and it then becomes a very important practical point, as they are of an opposite tendency, and require very different modes of treatment.

The measles, in every part of their course, exhibit an inflammatory aspect, and indicate the antiphlogistic regimen. Unless the constitution be predisposed to pulmonary affections, the disease be unusually severe, occur in very early infancy, or under some peculiarly disadvantageous circumstances, Rubeola is not a very dangerous complaint, but it is one in which it is necessary to act, in the earlier stages, with promptness and vigour, as, if this opportunity be suffered to pass by, our remedies will be far less efficacious, or perhaps altogether inapplicable. The degree to which we are to carry the antiphlogistic system must be determined by the circumstances of the individual case, by the character of the prevailing epidemic, the season of the year, and other collateral circumstances. Bleeding, either general or local, will be often necessary; purgatives are always proper, and we are carefully to maintain a regulated temperature, avoiding the extremes of heat, but shunning the direct application of cold. Any circumstance which may cause the sudden disappearance of the eruption is always to be guarded against, as indicating a dangerous state of inaction in the sanguiferous system; and, should it occur, it must be removed by the means that were pointed out with respect to Small pox. The cough is sometimes so troublesome a symptom as to require particular attention; but, for the most part, whatever relieves the febrile state will relieve the affections of the chest. Attempts have been made to produce the disease by inoculation, but it does not appear that any great benefit is obtained, or that the disease, when communicated in this way, is mitigated in the same manner as it is in Small-pox.

Sect. XXIII. *Erysipelas.*

There are two other diseases, that are usually placed by systematic writers among the exanthemata, although it would appear without any sufficient claim to this situation, Urticaria or Nettle-rash, and Pemphigus. They both consist of peculiar eruptions, the former, as its name indicates, very much resembling the sting of a nettle, the latter consisting of large irregular vesicles. A degree of fever attends them, but it is uncertain what relation the topical bears to the general affection; and as they are diseases not very well characterized, and often so slight as not to become subjects of medical treatment, we have not much accurate information respecting them. Urticaria is generally conceived to depend upon a peculiar state of the stomach and bowels; and Pemphigus appears to be symptomatic of, or consequent to, a general morbid condition of the system. Their treatment chiefly consists in removing any obvious sources of irritation, and in restoring the healthy state of the digestive organs.

We have placed Erysipelas as an appendage to the genus Exanthema, because, although wanting some of its characteristic circumstances, it seems to be more allied to it than to any other class of diseases. It consists of a fever, which is succeeded, at a certain period, by a cutaneous affection; the fever is of the inflammatory type, is attended with a degree of drowsiness, or even sometimes with coma and delirium; the head and face are hot and swelled, and a considerable part of the surface is attacked with an inflammation, which frequently produces large vesications that become filled with a serous fluid; it usually appears on the face or on the extremities. This disease differs materially from the other Exanthemata, in occurring more than once to the same individual; indeed, when a person has been affected by it, he is ever afterwards peculiarly liable to its attacks. Its exciting cause is obscure; it attaches itself to particular constitutions, which, however, it is not easy to characterize, and seems to have some connexion with peculiar states of the atmosphere, as it is epidemic in certain situations, as in hospitals, or other places where numbers of sick are crowded together, and especially patients suffering from wounds or surgical operations. It is doubtful whether it be ever properly contagious; but, upon the whole, the evidence appears to be in favour of its not being so. It has been thought that, when the disease prevails epidemically, as in hospitals, its symptoms differ from those of the cases that occur sporadically, and that in the former instances it assumes altogether a different type, possessing more of the malignant or typhous character; we are inclined, however, to doubt this conclusion, and are more disposed to attribute it to the greater violence of the complaint under these circumstances, in consequence of which its primary symptoms are more highly inflammatory, and are therefore succeeded by a state of greater exhaustion.

Considerable difference of opinion has arisen respecting the treatment of Erysipelas, and especially respecting the question, whether the antiphlogistic plan is to be employed, and whether external cold is admissible; or whether there is the same danger to be apprehended from repelling the inflammation as in some of the proper Exanthemata? Perhaps no general answer can be given to this question, which will apply to all cases; in the first stage of the disease, the antiphlogistic treatment, both general and local, is the one which usually ought to be pursued, but afterwards a medium course seems to be the best; external warmth aggravates the fever, while the feelings of the patient, and the weakness which supervenes, are adverse to the employment of depletion, or of any considerable degree of external cold. General bleeding is often necessary at the commencement; and purgatives, in this, as in all febrile affections, form a very valuable remedy. Although it may appear to be indicated by the symptoms, yet topical bleeding is generally condemned, in consequence of the difficulty which sometimes exists in healing the wounds made by the leeches or the scarificator. Diaphoretics are commonly prescribed; but if they are administered so as to become sudorific, they aggravate the irritation of the surface. Small doses of opiates are often rendered necessary by the restlessness and agitation which attends the disease; and it is for the same cause peculiarly important to avoid all sources of irritation, or to remove them whenever they are present. When the disease terminates fatally, it appears to be from the inflammatory affection being communicated or transferred to the membranes of the brain; it is therefore of great consequence to prevent all those circumstances which might tend to lay the foundation for such a crisis, and to obviate the first appearance of any symptoms which indicate the impending danger.

SECT. XXIV. *Hæmorrhagiæ. Discharges of Blood.*

We now come to the third order of the Parhæmasiæ, the Hæmorrhagies, those diseases that are characterized by a discharge of blood, which is not the consequence of external violence or an obvious breach of the surface. As we have already remarked, there is considerable obscurity respecting the proximate cause of hæmorrhage; but it may be stated to consist essentially in an irregular distribution of the blood, or a disposition of it to accumulate in certain parts of the sanguiferous system. It has been usual to divide hæmorrhagies into active and passive, as supposed to depend upon the relative degree of action in the vessels; and there seems to be a real foundation for this distinction, whatever may be our opinion concerning the immediate cause which gives rise to the two states. We do not presume to clear up this difficulty, but we conceive that there is sufficient ground for the opinion, that the former originates more particularly in some derangement of the arterial, and the latter in the venous part of the circulation. Upon this principle we have arranged hæmorrhagies under the two genera of arteriosæ and venosæ, an arrangement which we think may be usefully adhered to, both for the purpose of elucidating our theory and directing our practice; although at the same time it is admitted, that there are certain affections which it may be difficult to refer to their proper class, or that, under different circumstances, a discharge of blood may occur from the same part, which is at one time arterial, and at another venous. To the first genus we may refer Epistaxis, Hæmoptysis, and Menorrhagia, or the discharges of blood from the nose, the lungs, and the uterus; to the latter genus, the discharges of blood from the stomach, the intestines, the hæmorrhoidal vessels, and the bladder, and that peculiar affection of the skin termed Petechiæ. We have added, as appendages to the venous hæmorrhagies, the discharges of blood from the liver and the mouth, although it is probable that they are, in almost all cases, symptomatic affections.

Arterial Hæmorrhagies. Epistaxis, Bleeding of the Nose.

Epistaxis, when idiopathic, appears to be always an arterial hæmorrhage; and although, in consequence of its local nature, and the small size of the vessels concerned, compared to the whole extent of the sanguiferous system, it is seldom attended with fever, yet it seems always to be connected with an inflammatory tendency in the constitution, and is often followed by febrile affections, that ultimately prove of serious consequence. We must, however, observe, that blood is sometimes discharged from the nose, which appears to be of venous origin, but in this case it is always symptomatic, and consequent either upon great debility, or upon a tendency to decomposition of the solids, which, as we have had occasion to notice, exists towards the termination of various malignant fevers. Epistaxis is seldom so urgent an affection as to become the subject of medical treatment; it is generally sufficient to avoid the exciting causes, especially all those circumstances that produce an undue force or velocity in the circulation, as external heat, violent exercise, or intemperance in diet. The discharge may generally be restrained without difficulty by the application of external cold to the part, but if it recur frequently, and the state of the body appears to require it, we must have recourse to bleeding, and the other parts of the antiphlogistic regimen. It has been stated that Epistaxis is what has been termed vicarious, that is, the consequence of the ceasing of some other habitual discharge; perhaps this idea is not altogether without foundation, although we apprehend that it has been carried to a very extravagant length, in consequence of a false theory which prevailed on the subject; it may, however, be necessary to bear in mind the possibility of this occurrence, and to regulate our treatment accordingly.

SECT. XXV. *Hæmoptysis. Spitting of blood.*

All the remarks that we have made respecting Epistaxis will apply to Hæmoptysis, making allowance only for the greater size of the organ, and the function which it exercises giving a much greater degree of importance to any of its affections, and necessarily producing a much greater disturbance in the animal economy. The discharge of blood from the lungs seldom occurs, except in persons of the sanguine temperament, and in them is commonly the immediate consequence of some circumstance which excites the part to undue action, and produces an unusual determination of blood to it. The disease does not appear to be essentially connected with fever, and it often exists independently of the febrile state; but when it is severe, and frequently recurs, the symptoms of fever are generally excited, and these, in their turn, appear to aggravate the complaint. If the patient be not predisposed to pthisis by hereditary constitution, there is nothing in the nature of the disease which should necessarily render it of a fatal tendency; but it so frequently happens that it is connected with a phthisical disposition, as always to become the subject of great alarm.

Its cure consists, perhaps, more in carefully abstaining from all the exciting causes than in any very active practice. The quantity of blood that is lost by the discharge itself commonly renders bleeding unnecessary, and even purgatives, which we have so generally recommended in other affections of a febrile tendency, are sometimes scarcely admissible, in consequence of the irritation which is excited by their operation. Perfect rest, both of body and mind, abstinence, and an equable temperature, are perhaps the best remedies for Hæmoptysis; acids, especially the sulphuric, and various neutral salts, have been recommended, but we apprehend that the recommendation has originated from a false theory; and we doubt the efficacy of the practice. In certain cases of Hæmoptysis, where the circulation is at the same time, weak and quick, digitalis has been prescribed, and apparently with success: it must, however, be given in small doses, and its effects assiduously watched, as an overdose would produce a state of torpor, which might prove dangerous, both from its direct and its indirect effects. If the disease be attended with cough, we must employ those palliatives by which this affection is usually relieved, and if there be pain in the chest, blisters, or perhaps the topical detraction of blood will be necessary. In this complaint we are almost restricted from one of the most powerful means of restraining hæmorrhage, the application of external cold, in consequence of the apprehension that such a practice might produce Catarrh, or inflammation of the chest, which, under these circumstances, must be regarded as a very unfavorable circumstance.

Sect. XXVI. *Menorrhagia.*

Whatever may be our opinion respecting the nature of the menstrual discharge, or the use which it serves in the animal economy, we can have little doubt, that when it exists in excessive quantity, it is generally of that kind which we have termed arterial. It is generally attended with pain in the back and loins, and, when it has continued for any length of time, produces a febrile condition of the system, as manifested by the state of the pulse, and the other functions immediately connected with the circulation. The principal danger of Menorrhagia depends upon the immediate loss of blood, which is often so considerable as to reduce the vital actions to a very alarming state of debility; but it may be observed that, unless it arises from some structural disease of the organ, or is connected with pregnancy or parturition, when it becomes a symptomatic affection, it may usually be restrained by the proper application of remedies.—These are both general and local; the latter are employed to remove the urgent symptoms, and the former to prevent their recurrence.

In stopping hæmorrhage, the immediate object which we have in view is, to produce a coagulum at the mouths of the bleeding vessels, which, in this case, is principally to be accomplished by the topical application of cold. This, partly by its mechanical astringent operation, and partly by its sedative action on the vital powers, seems to diminish the flow of blood along the capillary arteries, and thus admits of the coagulation of the fluid which lies near their termination. Perfect rest, abstinence, and the means which were recommended in the other external hæmorrhages, are to be pursued in this complaint; and, in the same manner, we may employ the lancet, or may administer digitalis, where they seem to be indicated. There is often a degree of restlessness in this complaint which renders opium necesssary. We generally find that acids and neutral salts are prescribed, upon the principle of their being refrigerant; but this effect we are disposed to regard as altogether hypothetical.—The former, at least the citric acid, may be useful in quenching thirst; but the latter we conceive to be always injurious. Astringents and tonics of various kinds have been administered in Menorrhagia, with a view of securing the system against its recurrence. We are of opinion, that it is impossible to produce any astringent effect upon an individual organ through the medium of the stomach; and with respect to tonics, we may observe that their operation is of a critical nature. Perhaps, when the system has been much exhausted by the violence of the complaint, or where copious bleeding has been thought necessary to repress it, such remedies may be indicated; but we must bear in mind, that their effect is ultimately to produce that state of the system which will tend to lay the foundation for the return of the complaint. In most cases, a suitable attention to diet, and to those circumstances which are calculated to establish the healthy action of the digestive organs, will be found sufficient to recruit the system, and is the safer plan of proceeding. We think it may be questioned, how far there is ever an idiopathic Menorrhagia, which proceeds from absolute weakness of the part, although such a state is generally described by systematic writers; for it must be observed, that even where there is a general languor of the circulation, still a relative state of activity may prevail in the uterine system. If, however, such a state really exist, the stimulating plan would be improper, or, at least, of doubtful effect, notwithstanding it might appear to be indicated by the state of the constitution. We must abstain from depletion, or employ it with great caution, and are to trust to topical remedies, with the assiduous employment of those means which may confirm the general health without increasing the activity of the circulation.

Sect. XXVII. *Venous hæmorrhagies. Hæmorrhois, Piles.*

Although, considered either in a practical or a theoretical point of view, there seems no reason to doubt of the actual existence of venous, as distinct from that of arterial hæmorrhagies; yet they appear, in most cases, to be rather symptomatic than idiopathic affections, being either consequential upon some other disease, or indicating a structural derangement in the organ from which they proceed. This remark will, we apprehend, apply to the discharges of blood from the stomach, the intestines, the liver, and the bladder, which are, for the most part, either the effect of previous inflammation of these parts, or of actual disease in them, by which their mechanical texture is obviously deranged. The only means of relief, therefore, is to remove the morbid condition on which the discharge depends, when this can be accomplished; an object, however, which it is too frequently beyond our power to effect. Various palliative remedies have been employed in these cases, but we conceive without much prospect of relief; depletion is not indicated by the state of the system at large, nor do we apprehend that any benefit can be expected from the usual routine of astringents and tonics. Mild purgatives are useful, both from their local and their general effect, and opium may be given to allay irritation and to ease pain; but beyond these we have little to trust to, except the assiduous application of all those means which strengthen the digestive organs, and through their means tend to establish the general health.

There is, however, one of the venous hæmorrhagies which is to be regarded as an idiopathic disease, and which admits of a more direct and decisive treatment, hæmorrhois, or piles, consisting of a discharge of blood from the hæmorrhoidal veins. This disease has excit-

-ed a considerable share of attention, as appearing to coincide with the pathological hypothesis of the Stahlians, respecting the salutary efforts of the intelligent superintending principle, or *anima*. It was supposed that these veins afforded a kind of outlet for the superfluous fluids, when the sanguiferous system was oppressed with too large a quantity of blood, being analogous to the menstrual evacuation of the female, of which this was supposed to be the prime object. We have, however, no hesitation in asserting, that the facts upon which this hypothesis was built were much exaggerated, and that when we view the complaint without prejudice, we shall find it to be, like many others, in a certain degree useful in restoring the balance of the circulation, when it has been deranged by various circumstances, but, like them, always to be regarded as a disease which we must attempt to remove, and which, if suffered to proceed without restraint, lays the foundation for much future inconvenience.

We shall not in this place inquire into the causes which tend to produce congestion in this particular set of vessels; it will be sufficient to remark, that in certain constitutions, and at certain periods of life, the veins about the termination of the intestinal canal are liable to become distended with blood, that they are occasionally ruptured, and discharge their contents, and produce painful and even dangerous abscesses in the neighbouring cellular substance. When the veins are become turgid, it is necessary that they should be evacuated; and it is still more desirable that the turgescence should, if possible, be prevented from taking place. As the disease, although of a local nature, generally depends upon a constitutional cause, we are to use the most effectual means for reducing the plethoric state of the sanguiferous system; for this purpose the antiphlogistic plan must be employed, but rather in its passive than in its active form, for although bleeding and other depletions may be occasionally proper, we are to expect more permanent benefit from a temperate diet, a due proportion of exercise, and only a moderate indulgence in sleep. When there is much inflammation of the parts, leeches are often necessary; and when the discharge is very profuse, we may apply cold and astringents; mild purgatives are also indicated, both from their general and their local effect; and an opinion has very generally prevailed in favour of there being something peculiarly soothing in the operation of sulphur; we frequently find opium necessary to relieve the pain, which is often very severe. When these means have been neglected, or are found ineffectual, surgical assistance is required to remove the tumours, and to heal the ulcers that are occasionally formed; but these operations belong to a different department of the art. Although we do not admit the correctness of the hypothesis which regards Hæmorrhois as a salutary effort of nature, yet we conceive that where the system has been long habituated to such a discharge, if it be suddenly stopped, and no means of prevention be employed, bad effects may be the result. These, however, are easily obviated by using the necessary remedies against the plethoric state, which is then liable to be induced; perhaps general bleeding may be required, as well as purgatives, but we are to rely more upon exercise and temperance.

Of the two remaining diseases, which we have placed in this genus, Stomacace and Purpura, the first may be always regarded as a symptomatic affection, whether existing in the acute form, as we observe it in infants, connected with the disease which is popularly called Thrush, or in that more chronic state, appearing in connexion with Scurvy, or attacking individuals who have suffered from a long residence in hot climates. In both cases the cure depends upon restoring the healthy action of the alimentary canal, and the organs immediately concerned in the function of digestion.

Purpura is likewise, at least for the most part, merely symptomatic, appearing in the later stages of malignant fever, more especially in those where the component parts of the body seem to have a tendency to decomposition. Some cases, however, have occurred, where Purpura has existed without a proportionable degree of the febrile state, or indeed where this has been altogether absent, but they are involved in considerable obscurity; and we have little certain information respecting either their nature, or their immediate exciting cause. The same uncertainty also regards the cure of the idiopathic Purpura; for while we are told from high authority, that it is relieved by tonics, and especially by the mineral acids, we have equally respectable evidence in favour of blood-letting. Fortunately the disease is of rare occurrence, and therefore whatever regards either its cause or its cure, may be considered more in the light of a question of curious speculation, than of any great practical utility.

CHAP. II.

Neuroses. Primary Diseases of the Nervous System.

We now come to the Neuroses, the second great class of diseases—those depending upon a primary affection of the nervous system. As the phenomena of sensibility are more peculiar, and more unlike the other functions of matter, than even those of the muscular fibre, so its morbid affections are proportionally singular and difficult both to comprehend and to describe. The connexion which the different parts of the nervous system bear to each other, is one of its most remarkable properties, and it is exhibited in a variety of striking examples in its morbid states. We can generally assign to each of the Parhæmasiæ its primary seat, either by means of our sensations, or of some visible change which the part experiences, but in the Neuroses, we have neither of these circumstances to direct us; there is frequently no visible alteration in the structure of the part affected, while our feelings afford but little assistance in informing us of the original situation of the disease. The circumstance which must chiefly direct us in our arrangement of this class, is the degree in which the power exists, whether it be morbidly increased, or morbidly diminished, with relation to the standard of health; to this we have added another division of actions, which are simply irregular, without any regard to the mere quantity of effect produced. These three orders we have denominated, respectively, Erethismi, Astheniæ, and Spasmi.

SECT. I. *Hyperæsthesiæ. Affections depending upon an increased sensibility of the nervous system.*

We have divided the order Erethismus into the two genera of Hyperæsthesiæ and Autalgiæ; the first consisting in increased nervous sensibility, as manifested by the inordinate action of the external senses, or of the organic functions; the latter comprehending those diseases where there is pain in any organ, which, so far as we can judge, depends merely upon a nervous affection of the part. The diseases which seem to belong to the order Erethismus, and to the genus Hyperæsthesia, in particular, are many of them evidently symptomatic, or connected with some other disease, which is the principal object of our attention; yet occasionally, under these circumstances, the state of the nervous system itself becomes necessarily the main point towards which we are to direct our efforts. Thus, one of the most distressing effects in fever is want of sleep, and after we have removed the proximate cause of the disease, this sometimes still continues, and, by its harassing effects, prevents the complete re-establishment of the health. The same remarks apply to all those affections which consist in increased sensibility of the organs of sense, such as a morbidly acute state of the sight, the hearing, &c. or increased sensibility in parts that serve for the exercise of the organic functions, as the stomach and the kidney. For the most part we find them connected with some more general affection, which chiefly claims our notice, although, as we remarked above, they sometimes become the immediate objects of attention under these circumstances; and we must also bear in mind, that there are cases in which they indicate some local affection of the part or organ in which, although symptomatic, they are important, as indicating the existence of the primary affection, or assisting us in ascertaining its nature. Thus, a morbid increase of appetite, which is denominated Bulimia, is sometimes merely a symptom of Diabetes, and can in no degree be relieved by any palliative remedy; while at other times it originates from a disease of the stomach itself, which may be either structural or functional, and will of course acquire its appropriate mode of treatment. In the rapid sketch of the practice of medicine which we propose to offer to our readers, it will not be in our power, nor would it accord with our plan, to examine each of these affections in detail.

With respect to the method of proceeding in their management, the first point is, to ascertain how far the disease is primary or symptomatic; if primary, whether it depends upon a local cause of a mechanical nature, upon a visible alteration of structure, or upon an effect which operates through the medium of the system at large. If they are symptomatic, we inquire whether we are able to remove them by removing the primary disease, or by remedies appropriated to the removal of the nervous affection itself. It is not easy to lay down any general principles of treatment in a class of affections, which are so various in their origin, and depend upon such a diversity of causes. There is scarcely any condition of the system by which they may not be excited; and with respect to individual symptoms, they bear so little relation to their cause, that our judgment must be formed more from the general history of the case, and from a number of circumstances connected with it, than from any train of morbid actions which can be detailed, as constituting the essential character of the disease. The opposite states of plethora and inanition, of excitement, and of quiescence, sometimes produce what appears to be the same complaint, and must of course be combated in the individual cases, at one time by depletion and by sedatives, and at another by nutrients and stimulants. Generally speaking, however, we think that the modern practitioners have leaned too much to the latter class of remedies, biassed by their hypothesis of debility, which they have applied with so little discrimination to such a variety of diseases, and anxious to avoid the errors of the older writers, who ascribed nervous complaints to the affections of a subtile fluid, the existence of which they unfortunately neglected to ascertain before they assumed it as the basis of their pathology. We shall farther remark, that what are styled nervous diseases are, much more frequently than is commonly supposed, symptomatic of derangements of the digestive organs. Some remarkable examples of the effect which peculiar states of the alimentary canal produce upon the brain and nerves, are generally known; of which one of the most important is Hydrocephalus, and we are daily accumulating experience of the same kind, with respect to Epilepsy and various kinds of convulsions, when not proceeding from local or structural causes. Purgatives will therefore be always indicated in the Hyperæsthesiæ, if not by the immediate symptoms, at least as a means which is to be always tried, even although we proceed entirely upon empirical grounds.

After we have duly considered how far depletion may be indicated, and removed all local sources of irritation, we then proceed to the exhibition of sedatives, of which opium may be regarded as the prototype, and that which, for the most part, supersedes all the rest. The method in which this medicine operates, and the immediate effect which it produces, have been the subject of many volumes, and have formed the ground-work of some of the most violent and angry controversies of modern times. We have no space, nor indeed have we any inclination, for entering into these discussions; we shall merely state our opinion, that the operation of opium is primarily upon the nervous system, and that it acts upon it as a sedative. Its agency is equally extensive with the nervous system itself, and it is consequently experienced through the medium of so many organs and functions, that we have seldom an opportunity of witnessing its unmixed sedative powers, without, at the same time, observing some secondary effect, which may diminish, or even entirely counteract the primary operation. Thus, by lessening the sensibility of the intestines, opium tends to produce costiveness, and this retention of the fæcal evacuations may prove a greater source of irritation in certain cases, than the symptom for which the opium was administered. It is principally, perhaps, from this circumstance, that there is no remedy which is more uncertain in its effects than opium; and besides this, different individuals have remarkable idiosyncrasies with respect to it, which often interfere with the best regulated plans of the practitioner, and which cannot possibly be learned, except by a previous knowledge of the individual constitution of the patient.

Opium, when given in too large a dose, in an improper state of the stomach, or indeed to certain individuals under all circumstances, produces effects which are very similar to those of the vegetable poisons; and, on this account, it has always been a favourite subject of inquiry to discover a medicine which might possess the mere sedative effect of opium, without its deleterious properties. Hyosciamus, hop, the extract of lettuce, and other substances, have been proposed; but it may be doubted, whether every benefit may not be gained by a sufficient reduction of the dose of the opium.

Various preparations of opium have also been tried with the same intention; and upon one of these, called the black drop, in which the medicine is combined with a strong vegetable acid, great commendations have been bestowed from sources of very high respectability.

Sect. II. *Hydrophobia. Canine Madness.*

Notwithstanding the acknowledged obscurity which exists respecting the nature of this disease, we do not hesitate to place it in the genus Hyperæsthesia, as we think that the only consistent and probable hypothesis of its pathology proceeds upon the supposition of its originating in an increased sensibility of the nervous system. The exciting cause is well known to be a specific contagion, communicated by the bite of a rabid animal, and it appears to be always produced by means of the saliva being conveyed through the absorbents into the circulation. We conceive that the disease never originates in the human species from any other cause, although certain symptoms, in some measure resembling it, may have proceeded from other circumstances, but these we shall be disposed to refer to Hysteria. The question is not so easy to answer, whether Rabies be capable of being produced in other animals besides those of the dog and cat genus, although these, when affected, may communicate it to others, as to the human species, to horses, and to oxen. The disease commences by a peculiar feeling of anxiety, constant agitation, and unaccountable timidity; to these succeed difficulty of breathing, pain and constriction in the region of the stomach, and all over the abdomen, together with the characteristic symptom of an inability to swallow fluids, which soon extends to deglutition generally, and becomes so distressing as to impress the mind with extraordinary terror at the very idea of renewing the attempt. As the disease advances the pulse becomes weak and quick, and a degree of irregular fever supervenes; all the functions which depend upon the nervous power are rendered morbidly acute; there is intolerance of light and sound, the surface becomes exquisitely sensible to the impression of cold air, while towards its termination there is a copious discharge of viscid saliva from the fauces, the mental faculties are deranged, and general convulsions, with a total destruction of all the actions, both animal and organic, are the immediate forerunners of dissolution. The disease is rapid in its course, and most dreadful in its symptoms and aspect, yet its real horrors have been exaggerated by the terror and superstition of those who have witnessed it. The accounts which are met with in the older writers, of the violent fury of the patients, and of their attempts to sieze the by-standers, are probably altogether fictitious; and the dread of water, which has been viewed in so mysterious a light, is found to arise simply from the extreme uneasiness and difficulty which the unhappy sufferer feels in the act of deglutition.

With respect to the event of the disease, we believe it to be always fatal; not only has no cure yet been discovered for it, but it is doubtful whether we are in possession of any plan of treatment, by which its symptoms, when once established, can even be alleviated. The general mode of treatment has been the administration of large quantities of opium, upon the obvious principle of the nervous system being in a state of preternatural excitement; mercury has been given under various forms, but we know of no rational indication, either from theory or experience, which can lead us to expect any benefit from it, while lately very profuse bleeding has been employed, but we fear with a fallacious prospect of success. Besides these, which may be considered as the most powerful remedies that have been had recourse to, a great variety of palliatives, and a still greater number of nostrums, have been made use of; for in proportion to the violence and untractable nature of the disease, so has the credulity of mankind led them to place confidence in the most gross and scandalous impositions. But, although we have had such little success in the cure of Hydrophobia, we have happily in our hands a preventative, which in most cases is of easy application, and of tolerably certain effect; this is the excision of the wounded part, and the complete removal of every portion of the substance, which can be supposed to have been in contact with the saliva of the rabid animal. When, however, this has been neglected, when, from the situation of the wound, it could not be accomplished, or when, from any other cause, the disease makes its appearance, we cannot remain inactive spectators of so much misery, and naturally inquire what plan of treatment promises the least prospect of success, or may seem in any degree calculated to relieve the sufferings of the patient. To this question we are not able to return a satisfactory answer; we do not place the smallest reliance upon any of the numerous specifics that have been proposed, nor do we feel much more hopes from the effect of depletion, from opium, or from mercury. Guided, however, by the faint analogy which presents itself, we know of no treatment which is more promising, and therefore feel justified in beginning with a very copious bleeding, which is to be followed by a powerful mercurial purgative, and, when this has operated, by large doses of opium, combined with an equal quantity of calomel. We think it extremely important that perfect quiet should be enjoined, that all motion should, as much as possible, be avoided; and especially all unnecessary touching or handling of the patient. On this account, we conceive that frictions may be injurious; and indeed we think that any remedy which is merely indifferent, and is not given to promote some definite purpose, ought to be abstained from, as likely to do mischief, from the circumstance of its exciting the patient, or giving him any unnecessary cause for the exertion either of his mental or his corporeal powers.

Sect. III. *Autalgiæ. Painful nervous Affections.*

We have formed our second genus of the order Erethismus of the Autalgiæ, those diseases which depend upon a primary affection of the nervous system, and which are characterized by severe pain and uneasiness in the part affected. These are frequently symptomatic, but we are often unable to perceive any more general complaint to which they may be referred; and even where this is the case, the violence of their symptoms require our attention to be immediately directed to the local affection. The diseases which we shall enumerate under this genus are, Neuralgia, Cephalalgia, Prosophalgia, Otalgia, Odontalgia, Mastodynia, Pleurodyne, Gastrodynia, Arthopuosis, Sciatica, and Pruritus, to which we ought perhaps to add Lumbago. From a view of this list, it will appear that these affections are often attendant upon, or a consequence of inflammation, and sometimes arise from structural derangement; yet we have in some cases the most equivocal evidence, from the effect of remedies, that the disease is seated in the nerves of the part. We particularly refer to that most painful affection Prosophalgia, or, as it is popularly termed, Tic doloureux, where the disease may be clearly traced along the course of a particular nerve, and is at least for a certain period entirely removed by dividing the trunk of the nerve. In order to form a correct judgment of these complaints, it is particularly necessary to make ourselves acquainted with their history and symptoms from the commencement, otherwise there will be danger of our confounding the cause with the effect. In some of them, where the primary derangement is most evidently in the nervous system, we find obvious symptoms of increased action in the blood-vessels to supervene; and it even appears that a more permanent alteration in the structure of an organ may be produced by an affection, which, in the first instance, was simply attached to the nerves of the part. It is difficult to explain the nature of the operation by which a disease of the nerves is converted into one of the sanguiferous or secretory vessels; but we apprehend there can be no doubt of the fact, and we believe that it may be even affected by the mere influence of mental impressions, if they be sufficiently powerful, and steadily directed to the same part.

The cure of the Autalgiæ necessarily depends upon a number of minute circumstances which are connected with the local situation and functions of the organ affected; and in some of them there are certain remedies of a specific nature, which it is not easy to account for upon general principles, of which the use of the oxide of bismuth in simple pain of the stomach may be adduced as an example. In deciding that the disease is either idiopathic, or that it must be made the object of direct medical treatment, we first inquire whether there are any symptoms of inflammation which may render depletion necessary, or the other means by which we subdue the inflammatory action; we then apply blisters, issues, or other stimulating remedies, upon the principle of exciting what is called counter-irritation, proceeding upon a general law of the animal economy, according to which we remove a morbid action, by substituting for it a new, and probably a more considerable one, in some contiguous part, which latter is attended with no dangerous consequence, and which we have it in our power to remove at pleasure. In the Autalgiæ, as well as in the Hyperæsthesiæ, purgatives are generally useful, although perhaps not so universally; and opium, if it does not accomplish a radical cure, is at least one most effectual means for affording temporary relief. It has been observed, that some of the most severe pains to which the human frame is liable, recur at periodical intervals; and it has been found that in these, as in all other periodical diseases, bark, and even arsenic, may be employed with success; this latter remedy, however, we should not be disposed to try, until all other methods had failed; and it should likewise be accompanied by proper evacuations. Of their mode of operation, as well as of the circumstances which tend to give the diseases in question their periodical character, we are totally ignorant, and our practice, in these instances, is entirely empirical.

Sect. IV. *Nervous Fever.*

The second order of the Neuroses is Asthenia, including those diseases which consist in a diminution of the nervous energy; and under this we include three genera, the first of which is simple Nervous fever. We are aware of the apparent incongruity in placing the different kinds of fevers in different classes, and in supposing them to proceed from totally different causes, connected with a different set of functions, more particularly as it must, at the same time, be admitted, that the two diseases slide into each other by almost imperceptible degrees, so that it is often extremely difficult to know into what class any particular case ought to be referred. But, notwithstanding these objections, we are clearly of opinion that certain sporadic cases of fever, as well as certain general epidemics, exhibit symptoms which may be supposed to arise from a primary affection of the nervous system, while the sanguiferous system is but little affected, and that the two fevers are not merely different gradations of the same species of disease, in which the proportion between the symptoms remains the same, while the degree of both is equally diminished. We think it is not difficult to perceive a difference in the exciting cause, as well as in the effect produced; for while contagion is probably the sole cause of the proper Typhus, or putrid fever, the nervous fever never arises from this source, but from mental agitation, from over-fatigue, from complete exhaustion, or from other circumstances which might be expected to act upon the brain and nerves, more than upon the heart and arteries. The symptoms, and general character of the two diseases, when we take the most strongly marked cases, are no less easy to discriminate from each other. In the Nervous fever we do not observe the successive stages which we have in Typhus; there are no marks of oppression or congestion, nor of the subsequent attempt at reaction; but, from the very commencement, there are indications of weakness and irritability, the pulse quick and feeble, the heart little affected, not much thirst or disorder of the alimentary canal, except a less relish for food than ordinary; while, on the contrary, we have delirium, and all that derangement of the sensations, which indicates an irregular action of the brain and nerves, but, at the same time, without any appearance of turgescence in their vessels, or of that oppression which arises from a congestion of the fluids.

In the cure of Nervous fever, we must refer to the same principles which we have laid down with respect to its pathology; we require no general depletion, but we begin from the first with stimulants and excitants, exhibited in moderate doses, and proportioned to the effect which they have in rousing the dormant powers of the system. It is obviously of great importance to remove, if possible, the exciting cause, when it still remains applied, and in the later stages of the disease we must have recourse to stimulants and tonics, and shall find the proper management of the diet a most effectual part of the medical treatment. It is in fevers of this description that wine becomes a valuable remedy, and it is often found more grateful to the stomach than any stimulating compound which we can procure from the apothecary. It would have been fortunate for mankind if its use had been restricted to this disease, and had not been extended, by a false or imperfect analogy, to other affections which it resembles scarcely in any thing but in name.

Sect. V. *Anæsthesiæ.*

The second genus of the Astheniæ, Anæsthesia, is divided into complaints which consist in general debility of the nervous system; defects of the external senses, not depending upon a change in the structure of the organs; and in debility of the organic functions. The two first of these subdivisions may, almost all of them, be considered as symptomatic of some more general affection; the latter, under which we include Aphonia, Dysphagia, Anorexia, Dysuria, and Anaphrodisia, are not unfrequently primary, although at other times, like the former, only symptomatic. They depend occasionally upon an obvious change of mechanical structure, when they properly belong to a different part of the nosological system, and must be removed by mechanical remedies, as is frequently the case with Dysphagia and Dysuria. When, however, they are merely nervous affections, the cure is to be accomplished upon the same general principles which were detailed above, regard being always had to the local situation and specific functions of the part.

Sect. VI. *Apoplexia. Apoplexy.*

The third genus of Asthenia is formed by the Dyscinesiæ, those diseases which essentially consist in a loss or diminution of the power of voluntary motion, arising, for the most part, from an organic derangement of the brain; we include under it the species Apoplexia, Paralysis, Hydrocephalus, and Lethargus.

Apoplexy is characterized by a sudden abolition, or considerable diminution of both the external and the internal senses, and of the power over the muscles of voluntary motion, while the circulation and the organic functions continue to perform their actions. The pulse is, however, slow and oppressed, and the inspiration performed after long intervals, and accompanied by stertor, while the countenance is flushed, and the sensibility so much impaired, that the patient is unconscious of the most powerful impressions that can be made upon him. The immediate cause of Apoplexy appears to be, almost in every instance, the effusion of blood or serum on the surface of the brain, or into some of its cavities, which may be supposed to compress this organ, and thus prevent it from performing its due functions. Occasionally, however, we observe persons to be attacked with symptoms which have every claim to be considered as apoplectic, where, from the complete and very speedy recovery that takes place, we are unavoidably led to conclude that no considerable injury has occurred to the structure of the brain, an opinion which has been confirmed by some cases of dissection, although it is obvious that such opportunities can only be of accidental occurrence, where the patient has died from some other cause soon after his recovery from the Apoplexy. The state of insensibility which is occasioned by complete intoxication is very similar to Apoplexy, so much so, that except from the previous history of the case, from the length of time which it continues, and from the odour exhaled by the breath, we have frequently great difficulty in discriminating between these affections, although arising from such very different causes, and producing such different ultimate effects upon the system. Persons who have suffered from Apoplexy are observed to be of a peculiar temperament or bodily conformation; they are generally corpulent, with short necks, and large heads, and exhibit various indications of a torpid state of the blood-vessels, attended, at the same time, with considerable force of the circulation, and firmness in the texture of the components of the body. According to the nature of the fluid which is effused, whether it be entire blood or only serum, the disease has been divided into the two varieties of sanguineous and serous, and it seems that this division has an actual existence, but we doubt much whether we have any certain means of ascertaining them before death from the symptoms of the case.

The proximate cause of the disease is supposed to be a congestion of blood in the vessels of the brain, generally terminating in effusion; it has been a controverted question, whether a proper Apoplexy can be produced by the mere accumulation of blood in the vessels, without absolute effusion taking place, a question which we should be disposed to answer in the affirmative, although it is difficult to prove the point by a reference to dissection, because, when there is no actual rupture of the vessels, recovery may be supposed generally to take place, so as not to admit of our examination. The exciting causes of Apoplexy are various, but may, for the most part, be referred to those circumstances which increase the impetus of the blood through the arteries of the head, or retard its egress from them. Violent exercise, sudden fits of passion, severe mental exertions of all kinds, certain postures of the body, the direct application of the sun's rays to the head, blows, or mechanical injuries of the part, and especially intemperance in eating or drinking, are among the most frequent causes assigned for Apoplexy, and may be obviously accounted for upon the above principle. There are, however, other causes, such as narcotic poisons, metallic fumes of various kinds, some of the unrespirable gases, especially the carbonic acid, and intense cold, which, although they induce the symptoms of Apoplexy, may perhaps be supposed to act upon the nervous system generally, by diminishing the sensibility of all its parts, rather than by producing any local affection upon the brain in particular. After a severe attack of Apoplexy, except it arise from some obvious external cause, the functions, both of the body and the mind, seldom regain their former vigour, and, for the most part, either one side of the body is left without motion, constituting what has been termed Hemiplegia, or the whole of the voluntary motions and mental powers continue in a very imperfect and enfeebled state. We have sometimes curious instances of the loss of individual faculties, as the memory of names, of dates, or of places, and occasionally of a particular language: such cases have given rise to many pathological and metaphysical speculations, but these do not hitherto appear to have been sanctioned by the results of our anatomical examinations.

The cure of Apoplexy consists first in removing the exciting cause of the disease, should this still remain applied, and afterwards in endeavouring to relieve the congestion of the vessels. This last is attempted by large bleedings, which are thought to be more effectual when the vessels near the head are opened, such as the jugular vein or the temporal artery; we may also take blood from the cutaneous vessels by the scarificator or by leeches, and afterwards apply large blisters to the neck; along with these drastic purgatives are to be given, so as to procure a free evacuation from the bowels. Where the disease appears to have been immediately produced by repletion of the stomach, or by any noxious substance received into it, an emetic will be proper, but in other cases vomiting is thought to be rather injurious, or at least does not seem to have any claim to be considered as a remedy of general application. When depletion has been carried as far as has been thought necessary, or as the state of the patient will justify, little efficient treatment remains to be employed; stimulants must at first be used with great caution, as any degree of over-excitement might bring back the original complaint; the longer the disease has continued the more freely they may be given; but it must at the same time be confessed, that we can have less expectation of benefit from them. Upon the whole, if the complaint be not relieved, either by the efforts of nature, or by the operation of our remedies, soon after its first invasion, we are not to hope for much advantage from any thing that can be done in future, but must confine ourselves to relieving particular symptoms, and soothing the helpless condition of the patient, by an attention to a variety of minute circumstances, for which no general rules can be prescribed.

Sect. VII. *Paralysis. Palsy.*

Paralysis may be regarded as a partial Apoplexy, and is, in most instances, the sequel of that disease, when it does not terminate fatally. The two diseases originate from the same causes, and commence nearly with the same symptoms, in the most severe kind of Palsy; but besides these, we have partial Paralysis, sometimes of a single limb, or even of a single muscle, which proceeds entirely from some local injury of the nerves of the part. We have also another variety of Palsy, in which the affection is general, but less violent, where there is no sudden seizure, and where the loss of sensation and motion is not complete in any one part, but where there is a degree of weakness over the whole body, and especially in the voluntary muscles, accompanied by tremor, partial convulsions, numbness, and frequently by a general wasting of the part. This kind of Paralysis is the consequence of the excessive use of opium, or a too free indulgence in ardent spirits, and is occasionally observed to come on in old age without any assignable exciting cause. In the more severe cases of Palsy, and in those that are left after an apoplectic attack, we usually find that exactly one half of the body is affected, constituting the variety of Hemiplegia; and upon dissection we find, in most of these cases, that the injury to the brain is on the opposite side to that of the paralytic limbs, a fact which has been much employed by those who have speculated upon the pathology of the nervous system. Another variety of Palsy is Paraplegia, where the diseased is separated from the sound part of the body by a transverse section; this proceeds, in almost all cases, from an injury to the spine, and of course the extent of the disease depends upon the part in which the spine is affected.

Where the Paralysis occurs in its violent form, or is the sequel of Apoplexy, its treatment must, in every respect, coincide with what was recommended above for this complaint: we must begin with copious depletion of the sanguiferous system, then administer active purgatives, apply blisters, and gradually have recourse to stimulants. But, in many cases, the accession of Palsy does not indicate that state of the blood-vessels, which leads us to suppose that bleeding is necessary; and although, perhaps, purgatives are always proper, we place our chief reliance upon the stimulating plan, after we have done all that lies in our power to remove the exciting cause. The stimulants that have been employed in Palsy, both general and local, are very numerous; the choice must depend upon circumstances connected with the nature of the constitution of the patient and the part affected. They consist both of various articles of the materia medica, and of different mechanical applications; among the former, we may enumerate ether, and spirituous compounds, lytta, oleum terebinthinæ, ammonia, sinapis, the warm essential oils, and the whole class of vesicants, and rubifacients. Among the more efficacious of the mechanical applications, is friction in various forms, hot fomentations, electricity, and galvanism, a remedy which, however, has not answered the high expectations that were formed respecting it; the natural thermal springs are had recourse to with benefit in the later stages of Palsy.

It would be incompatible with our object to point out the means employed for removing the various local causes of Palsy; but there is one that is connected with diseases of the spine, which forms so important an object of our attention, as to require being distinctly noticed. When the disease occurs spontaneously, it has been conceived to originate from a scrofulous tendency in the constitution, and it must therefore be combated by all those means which are supposed to be useful in counteracting this tendency. Practitioners, however, are but too well aware of the little benefit that is to be derived from the most approved of these means, and generally all that lies in our power is to endeavour to remove the local complaint, and this has been usually attempted by the application of caustic issues near the part affected. A new plan of treatment has been lately proposed, in which, instead of issues, the patient is strictly confined, for a great length of time, to the horizontal posture. When we consider the nature of the affection, and especially when we perceive the ravages which it commits in the structure of the bones, we can scarcely imagine how mere rest, although a powerful adjunct, can alone perform a cure, and we are led to conjecture, that in those cases where this plan has been successful, the symptoms depended simply upon weakness, or a loss of voluntary power, arising from a nervous affection, but without any structural disease. In Palsy of long continuance, where the original cause of the disease is removed, and where the structure of the part is irremediably injured, it has been found of great importance for the patient to use as much voluntary exertion as possible in the affected muscles, and in this way the healthy action has been restored in parts which were previously almost quite useless.

Sect. VIII. *Hydrocephalus. Water in the Head.*

We have placed this disease in the genus Dyscinesia, although it is in fact a species of dropsy, because both its symptoms and its treatment connect it more with the primary diseases of the nervous system, than with those of any other part of the animal economy. The origin of this disease, and its predisposing causes, are obscure: it affords a remarkable instance of the existence of a peculiar train of symptoms, indicating an affection of a part remote from that whence they might naturally be supposed to proceed, and of the sympathy between two parts, not related to each other by their local situation, or by any obvious action of their functions. The disease, when it exists under its usual form, commences with fever, violent pain of the head, characterized by an acute darting sensation, which is generally felt in the temples or across the forehead; great sensibility to light and noise, extreme agitation and restlessness, with the expression of sudden paroxysms of severe suffering; along with these symptoms there is great derangement of the digestive organs, vomiting and obstinate constipation, with a peculiar morbid appearance of the evacuations. After these symptoms have continued, the state of excitement appears to be succeeded by one of oppression; there is a considerable degree of coma and stupor, while the pulse becomes preternaturally slow, the pupils dilated, and the bowels still more torpid. The indications of severe suffering are exchanged for those of insensibility, and at length a complete state of Paralysis supervenes, and announces the near approaches of death. The acute disease is seldom, if ever, found after the age of puberty: it has been supposed, although, as we think, without sufficient foundation, to be connected with a tendency to Scrofula or Rickets; it is, however, hereditary, and therefore may be conceived to attach to some original peculiarity in the structure of the body. Its exciting causes are not well ascertained; for although it may occasionally appear to follow an injury of the head, in most cases we are unable to trace it to any thing of the kind. With respect to its proximate cause, we apprehend it must be regarded as originating in an inflammatory action of the capillaries of the brain, although probably of some specific kind, and that the effusion of the fluid is the consequence of the increased action of the vessels. In what consists the essential difference between Hydrocephalus and Phrenitis is not well ascertained, whether upon a different set of vessels, or upon a different action of the same vessels; the diseases are, however, in all respects very different from each other, both with respect to their symptoms and their treatment. The connexion which we observe between the state of the alimentary canal and the head is difficult to explain; and what increases the difficulty is, that symptoms which very nearly resemble those of Hydrocephalus not unfrequently exist, where it would appear that the head is not actually the seat of disease, and which are referred to the effect of worms. But every thing that respects the existence of worms, or the symptoms which they produce, is very obscure, and is so much involved in empiricism, that we are always at a loss to determine what degree of credit is to be attached to the statements that are made on this subject. Upon the whole, we are disposed to consider the peculiar state of the bowels as partly the cause and partly the effect of the condition of the brain, and, as far as regards the point of practice, whichever is actually the primary disease, the plan of treatment is not materially different.

The cure of Hydrocephalus is to be attempted by diminishing the over-excitement of the vessels of the brain, and by restoring the action of the alimentary canal. The first is to be attempted by blood-letting, which is generally local, and which must be persevered in as far as the strength of the patient, or the other circumstances connected with the case, will admit, but which is seldom effectual, unless it be carried to an extent which would not be justified under less urgent circumstances. Purgatives are to be also administered with steadiness and perseverance, until the evacuations assume a more natural aspect, and it is generally agreed, that they are more effectual when calomel enters into their composition. Along with these, which are our principal means of relief, we apply blisters to the head and neck, with external cold, and likewise give such remedies as may be indicated by the general state of fever, or by any other peculiarly urgent symptoms. These remedies are to be used in the first stage of the complaint: should this be passed by, and the symptoms of effusion manifest themselves, we believe that every means will be unavailing, but still it is our duty to attempt what offers the most probable chance of relief, and among the remedies which have been recommended at this period is mercury, given so as to produce its specific effect upon the system. How far we are still to use blood-letting is a question which must be decided by the symptoms of each individual case, but the assiduous use of purgatives will still be proper; we must, however, be careful, lest, in our eagerness to administer medicines, we aggravate the sufferings of the patient, and, by an ill-directed solicitude, disturb the short remaining period of his existence.

Besides the disease which we have now been describing, which is altogether of a very acute kind, there is a chronic Hydrocephalus, where the disease comes on so slowly as scarcely to produce any general affection of the system. The bones of the skull in these cases gradually give way to the pressure of the fluid effused in the interior parts of the brain, and the head becomes enlarged to a degree which would have been supposed incompatible with the exercise of any of the functions, or indeed with the actual continuance of life. This complaint is irremediable, or, if any relief can be obtained, it must be by hazarding an operation which promises so little advantage, that nothing but the miserable state of existence in which the patient is reduced by the disease could sanction the experiment.*

* Hydrocephalus may most justly be considered an inflammatory affection of the brain. It often approaches very insidiously, having its primary seat not in the membranes, but in the parenchymatous portion of that organ. Like other inflammations seated in soft parts, it is frequently overlooked both by the patient and physician, until effusion has actually taken place from the inflamed vessels, when we can do little more than diminish the sufferings of the patient, which in that state are very acute. It is certain that Hydrocephalus is a much more frequent complaint, since the more general use of mercury, particularly as prescribed in the diseases of children. The observations of Blackall, Beddingfield, Wright, and Pemberton, on the increase of excitement produced by mercury, and the aggravation of inflammatory diseases by the use of that metal, are an additional evidence of its injurious effects in Dropsy of the Brain. In several instances, the writer has seen Hydrocephalus as the result of the infantile remittent fever, which, in its commencement, was overlooked by the practitioner, and its termination in Hydrocephalus has been made the cloak for his ignorance. The frequent observance of this fact has led us to divide Hydrocephalus into two species; idiopathic, traceable to predisposition from hereditary conformation of the brain; and symptomatic, the effect of injuries of the head, febrile and other diseases, more espe-

Sect. IX. *Spasmi Epilepsia. Epilepsy.*

After the two first orders of the Neuroses, including the diseases that are characterized respectively by an increase, and by a diminution of the nervous power, we come to the third order, where it is exercised in an irregular manner; to these we give the name of Spasmi. We derive the genera of the Spasmi from the relation which the part affected bears to the exercise of volition, into diseases of the voluntary muscles, the involuntary muscles, and those which possess a middle rank between the two. One of the most important of the species belonging to the first genus is Epilepsy. This disease may be shortly defined a sudden accession of violent convulsions of the whole body, with a loss of sensation and voluntary motion. Each attack continues for comparatively a short period only, when the patient recovers his usual state of body and mind, and experiences a degree of stupor and drowsiness, but without any recollection of what has passed. Although, however, the effect of a single fit is not productive of any visible change upon the animal economy, yet, when the disease recurs frequently, and the attacks are violent, the functions that depend upon the nervous system gradually become weakened, and ultimately much deranged, so as to bring on imbecility of the mental faculties, and an imperfect power over the voluntary muscles. It has been usual to divide Epilepsy into idiopathic and sympathetic; the latter being supposed to depend upon some obvious exciting cause; but we do not apprehend that there is any real foundation for this division; it in fact amounts to no more than that in some cases we are able to detect the exciting cause, while in others we are ignorant of it. The exciting causes appear to be very various, originating from a great number of different circumstances, that bear different relations to each other, and all produce nearly the same symptoms. Those that generally fall under our observations are, 1st, Injury and malconformation of the skull, or the parts included in it; 2d, Certain states of the alimentary canal, particularly worms, or that morbid condition of their contents which is supposed to be favourable to the production of these parasitical animals; 3d, The peculiar irritation caused by teething; 4th, Violent mental emotions, especially surprise and terror; 5th, Repeated intoxication; and, lastly, an hereditary tendency in the constitution, which we are not able to describe or define, although we can have little doubt of its existence. The invasion of Epilepsy is sometimes so sudden, that the patient has not the least warning of its approach, but falls down at once in a state of complete insensibility; at other times there is a feeling of oppression in the head, with vertigo, dimness of sight, and confusion of thought, and occasionally there is a peculiar sensation of cold, which has been named the aura epileptica, passing up from some part of the body to the head, when the complete paroxysm comes on.

As the disease seems to originate from such a variety of causes, so its prognosis is extremely uncertain, and its cure has been attempted by a great variety of means. When the exciting cause is clearly ascertained, we, of course, direct our whole attention to the removal of it; and the success of our attempts in this way must entirely depend upon the degree in which this can be accomplished. When the cause is not obvious, we have but little to guide us in our operations, except a reference to the general state of the functions, and some analogies which are too often very obscure and uncertain. The state of the bowels is one of the first things to be attended to; and, in children, we are often able to remove very formidable attacks of the disease, by completely evacuating the alimentary canal. It is generally the custom to make calomel one of the principal ingredients in the purgatives that are administered in Epilepsy, and it is probably used with more advantage when united to jalap, scammony, colocynth, or some of the drastic medicines of this description. When the digestive organs seem to suffer from acidity and flatulence, or from any other particular symptom, we are to endeavour to remove them by the appropriate remedies; and when there is a general weakness of the digestive organs, we employ, according to circumstances, stimulants, stomachics, and tonics. It has been proposed, in those cases where the fit is preceded by the aura, to cut off the communication between the part whence the peculiar sensation proceeds and the brain, by compressing the nerve, or even dividing it; but it is doubtful how far this practice has been attended with success, or how far we ought to expect any benefit to be derived from it. When there is no obvious exciting cause, and when the different organic functions do not exhibit any evident irregularity, we can have but a faint prospect of removing the disease; and our practice must, for the most part, proceed entirely upon empirical principles. In this, as in all other similar cases, we find, that in proportion to the obscurity of the complaint, and the real difficulty which there is in relieving it, so is the number of infallible remedies that are held out to the hopes and fears of the unfortunate sufferers. The remedies that have been proposed for Epilepsy, under this form of the disease, may be divided into three classes; those that are called antispasmodics, generally possessing some property that powerfully affects the external senses; tonics, and a miscellaneous description of remedies, which can only be referred to their power of acting upon the imagination. Some of the principal antispasmodics are ether, valerian, castor, and musk, to which it has been the custom to add opium, and various other sedatives In certain cases of convulsions, we conceive it not impossible that benefit may have been derived from these substances; but we have no conception that they can have any great power over proper Epilepsy. The second division of remedies, the tonics, although of very problematical operation, possess more claim upon attention. Of these the most powerful are certain metallic salts, as the nitrate of silver, cuprum ammoniatum, the oxide of zinc, and various salts of iron and arsenic. In what manner these

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cially such as occur in early life, when the undue determination of blood to the brain is an ordinary occurrence. When Hydrocephalus can be detected in its forming stage, much may be done, not by the usual medicine, mercury, but by the lancet, cupping, a blister covering the scalp, by active saline cathartics, and by other means of depleting the system and restoring the natural excretions. The practice of administering mercury in Dropsy of the Brain cannot be too severely reprobated. It has again and again been the cause of the disease, when administered for worms, and in other complaints where the patient did not previously manifest the least tendency to an affection of the brain.

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substances act, and for what particular varieties of the disease, or states of the system, they are each of them more particularly serviceable, are points on which we have little certain knowledge. Vegetable tonics are among the remedies usually prescribed for Epilepsy; of these cinchona may be supposed to supersede all the rest, although, by way of giving variety to our prescriptions, we may substitute other articles of the same description, or may occasionally give them in combination. We have mentioned worms among the exciting causes of Epilepsy, and this appears to be the case more particularly with the tape-worm. As the oil of turpentine seems to act very powerfully upon these animals, we may be fairly allowed to try the effect of turpentine in all cases of Epilepsy that have baffled our other means, even when we have no evidence of the existence of the tænia, more especially as the indications of its presence in the intestines are not always very obvious.

Nearly allied to Epilepsy, and perhaps differing from it chiefly in degree, are the convulsions with which children are so frequently attacked, more especially about the period of dentition. These affections are generally removed as the exciting cause ceases to operate, and are not productive of any permanent injury to the constitution. It is, however, necessary to use the appropriate means for facilitating the passage of the teeth through the membrane that covers them; while, at the same time, it will be desirable to evacuate the bowels completely, and to be extremely guarded with respect to the diet. The paroxysm is supposed to be shortened or relieved by immersing the patient in the warm bath; and it is a remedy which may be always employed with safety, if not with advantage.

Sect. X. *Hysteria. Hysteric Disease.*

Hysteria is a disease of so multifarious an aspect, which exists under such a variety of forms, differs so much in its violence at different times, and is so peculiar in its nature, and in its effects upon the animal economy, that we feel some difficulty in giving a concise and summary account of it.

It usually occurs in fits or paroxysms, which considerably resemble those of Epilepsy, except that they are less violent, and that the consciousness is not altogether lost; but there is the same convulsive exertion of the limbs, and the sensations and mental faculties, although not entirely suspended, are much disordered and perverted. There is likewise in Hysteria a symptom which may be conceived to bear some analogy to the aura epileptica, which has obtained the name of the globus hystericus. It commences with a peculiar feeling of pain and distention in some part of the abdomen, which gradually rises up the course of the intestinal canal, until it reaches the stomach, and, finally, the upper part of the throat, where it remains stationary, and seems to threaten immediate suffocation. The convulsive affections now come on, and are attended with faintness and partial insensibility, while the patient laughs and cries alternately, exhibiting almost an appearance of delirium or fatuity, until the paroxysm is terminated by an eructation of flatus, to which succeeds a copious discharge of pale urine, and sometimes a degree of stupor and drowsiness.

The nature of the convulsions, as well as of the other symptoms, varies in all possible ways. Sometimes the limbs are rigidly fixed in one position; at other times they are violently agitated: occasionally there is a general stupor approaching to coma; at other times pains are felt, which are so violent as to cause the patient to utter the most horrid screams.

There is something very mysterious about the exciting causes of Hysteria. It appears, in many cases, to be merely a mental affection, induced by violent passions or strong emotions; and so much is this the case, that the patient is certainly able, by voluntary exertion, to prevent the accession of the disease, which, if it had been suffered to proceed in its usual course, would have assumed the formidable appearance that has been described above. The symptoms are frequently induced by a kind of imitation, where the sight of a patient labouring under the disease will bring a similar disease on the by-standers. These facts have led some persons, both professional and unprofessional, to consider Hysteria as always a fictitious complaint; one entirely under the control of the will; which, like the expression of anger, may be always restrained, being assumed for the purpose of exciting sympathy, or other similar motive. To a certain extent this may be true; but we apprehend that no one who has frequently witnessed the disease in its aggravated form, can suppose that it is always so. Indeed, we cannot conceive how any voluntary effort could produce the effects upon the various organic functions, that are so frequently observed in this disease, or that any thing, except a highly morbid condition of the animal economy, could enable the patient to perform the convulsive muscular exertions, which far exceed what is ever observed in the same individual at other times. It is well known that Hysteria is almost entirely confined to females, and, among these, it is generally met with in those of feeble muscular powers, but of great nervous sensibility. Some instances occasionally occur in the male sex, which we think are entitled to be classed with Hysteria, whose state of body and mind are most similar to the female constitution. We have already mentioned the resemblance which Hysteria bears to Epilepsy; and we conceive that it is often extremely difficult to distinguish between them, where the one disease appears in its mildest, and the other in its most acute form. The *globus* is not always present in Hysteria; and there are certain cases which seem entitled to the appellation of Epilepsy, yet where the insensibility is not complete, and where the state of the feelings and of the nervous functions very much resemble what has been described as characterizing Hysteria; and, besides this, the diseases are sometimes evidently convertible into each other, what begins under the form of Hysteria finally terminating in Epilepsy.

Hysteria, when it appears in its unmixed form, and is not the forerunner of Epilepsy, or symptomatic of any other disease, is seldom attended with danger, although it may be difficult to remove. Our indications are to prevent or cut short the paroxysm, and to obviate its return. The first is accomplished by any sudden impression upon the mind or the organs of sense. The general directions for this purpose it is almost impossible to lay down, as so much depends upon the peculiar circumstances of the case, both with respect to the bodily and mental constitution of the patient. A fit has been prevented by suddenly dashing cold water over the patient, by antispasmodics, carminatives, or stimulants, and by various means which only operate through the medium of the imagination. In order to prevent the return of the fit, we endeavour to restore the due balance between the powers of the system, by increasing strength while we diminish action. This is accomplished principally by tonics of various kinds, vegetable and metallic, of which, perhaps, the most efficacious is cinchona, combined with some preparation of iron. Among the auxiliary means, we may mention bodily exercise, the cold bath, abstinence in diet, early rising, and such other means as are generally allowed to invigorate the system, while, during the whole course of the disease, we are to be especially careful to preserve a very open state of the bowels.

Sect. XI. *Chorea. St. Vitus's Dance.*

This is a peculiar kind of convulsion, which principally affects the extremities, and generally the arm and leg of one side more than the other. It consists in a loss of voluntary power over the parts, so that the patient is unable to move them in the required direction, while they are subject to a variety of spontaneous motions, which he has it not in his power to restrain. Other parts of the body, especially the face, are subject to involuntary twitchings; and, when the disease is violent and has been of long standing, the speech becomes affected, and at length a degree of fatuity supervenes.

Chorea makes its first appearance almost exclusively in young persons, for three or four years previously to the period of puberty; but if it be not removed by proper remedies, it will continue, in a certain degree, for a long period, or even during the remainder of life. The patients are generally of a delicate habit of body, and such as have not enjoyed a sufficiency of nourishment, fresh air, or bodily exercise. It occasionally occurs in paroxysms, or, at least, is more violent at some times than at others; but generally its progress is gradual, first exhibiting itself in certain gestures or motions of the limbs, which seem rather objects of ridicule than of medical treatment. Sometimes the first symptom that is noticed is a dragging of the leg in walking, similar to what we obseve in slight paralysis. Along with the more appropriate symptoms we generally find, that the digestive organs are deranged, and especially that the bowels are torpid. The disease, in some cases, appears to be sympathetic of a local irritation, such as that from teeth or from worms; but, generally, we do not observe any local exciting cause to which it can be referred. It is said to be disposed to disappear spontaneously at the age of puberty, but we doubt the correctness of this observation.

The cure of Chorea has been attempted by various means that are very opposite to each other. By some authors depletion is recommended, while, by others, tonics and stimulants are prescribed; and in each case the remedies are directed generally with little regard to the nature of the individual cases, or the difference which may exist between them. This apparent inconsistency, perhaps, depends partly upon the nature of the complaint, which, like some others of the Neuroses, may arise from causes that are almost diametrically opposite to each other, and yet may exhibit nearly the same symptoms. The plan of treatment which we shall recommend is, that the state of the bowels be always the first object of attention; that brisk cathartics be administered, consisting of calomel combined with a drastic purgative, until the evacuations are of the natural quantity and quality. If the appetite be defective, we should then administer stomachics; and if the system exhibit marks of general weakness, we may employ tonics and stimulants. We believe that less advantage will be obtained from the use of opium and other sedatives, than the nature and the symptoms of the disease might lead us to expect; nor do we apprehend that much will be gained by the tribe of antispasmodics. The application of blisters to the origin of the nerves which supply the affected part, especially to the different regions of the spine, has been found a useful practice; mercury given so as to effect the system, has been strongly recommended by some writers, and likewise electricity; but we do not feel much confidence in either of these remedies. We need scarcely remark, that it is extremely important in all cases of Chorea to examine the state of the teeth, and to remove every probable cause of irritation which may seem to be derived from this source.

Sect. XII. *Tetanus.*

By Tetanus, in its most extensive sense, we mean a rigid contraction of any muscle or set of muscles; but it is usually applied to a general condition of the system, where all the muscles of the body, and especially those of the trunk, neck, and jaws, are in a permanently contracted state, so as to render the patient almost incapable of motion, speech, and deglutition, while the most acute pain is experienced in all the affected parts, and particularly about the pit of the stomach and over the abdomen. The disease is sometimes principally confined to the jaws and the neighbouring parts, when it is styled Trismus or locked jaw. It usually commences with a degree of stiffness in the back of the neck, with some difficulty in opening the mouth; to this succeeds the rigidity of the muscles of the trunk, where it is often so violent as to bend the body into the form of an arch, and it finally extends to the extremities. The disease is aggravated by paroxysms, which are generally, but not always brought on by some voluntary exertion, as by changing the posture, or by swallowing, when the contractions become much more forcible, and the pains more acute, until the patient is carried off in one of these accessions, exhausted as it were by his excessive exertions, and worn out by the violence of his sufferings. The exciting causes of the disease are of two kinds; the most frequent in this climate is a certain species of mechanical injury, not productive of much pain, but exciting a specific irritation, which, from some unknown cause, affects the nerves so as to induce the disease. Wounds of a nerve are perhaps the most frequent cause, but laceration of a tendon is also said to excite it; and it is often observed to follow gunshot wounds or surgical operations, in which large bones have been divided; in these cases it is generally supposed that a loose splinter of bone has been left in the wound, that a nerve has been torn, or perhaps included in a ligature. The other class of the exciting causes of Tetanus is even more obscure; it occurs principally in hot climates, and generally originates from those circumstances that are supposed suddenly to check the cutaneous perspiration, where the body is exposed to damp and cold after great heat; of these one of the most frequent occasional causes is sleeping on the moist ground, after violent exercise under a tropical sun. It does not appear that the symptoms of the disease in these two varieties are materially different, although arising from such different causes; but those of the latter kind, which are termed idiopathic, are, for the most part, less violent than such as arise from wounds or other mechanical injuries. Although fever is not an essential symptom of the disease, yet, after it has subsisted for some time, the pulse becomes accelerated and the temperature increased; and it has been supposed that the best means which we possess of forming a prognosis is derived from the state of the pulse, especially with respect to its velocity.

In attempting the cure of Tetanus, the first object is to remove the source of irritation, if it depends upon any obvious mechanical cause; if it proceeds from a wound of any kind, it has been recommended to divide the nerve which passes from the wounded part to the brain; but this practice has not been attended with the expected relief, nor has even amputation of the limb been successful, when the disease has once taken possession of the constitution. Applying caustics, or heating stimulants, as the oil of turpentine, to the wound, so as to produce a copious suppuration in the part, has been thought to afford a probable means of relief, upon the principle that where Tetanus has followed from a mechanical injury, the discharges have assumed an unhealthy aspect. It is, however, extremely doubtful whether any advantage has been derived from these practices, and at all events our main reliance is to be placed upon internal remedies, of which the most important is opium. When the symptoms of the disease unequivocally manifest themselves, we must immediately have recourse to this medicine in frequently repeated doses; the extent of the dose must depend upon the effect which it produces on the system; but the quantity which has been taken in this disease is very large, and much more than could have been borne in the ordinary condition of the functions. Many substances have been united with opium, upon the idea of increasing its efficacy, but it may be questioned whether they are of any essential benefit; perhaps indeed in those cases where there is much fever, a combination of opium and ipecacuanha may be preferable to opium alone. Some cases are upon record where idiopathic Tetanus has been relieved by dashing cold water over the patient, or by immersing him in the cold bath, but this has probably been in the slighter cases only, and in Tetanus from wounds has been found completely useless, perhaps even injurious; for in such cases the sensations of the patient rather indicate the application of warmth than of cold to the surface. Besides the internal exhibition of opium, it has been found to produce its appropriate action on the system, by being rubbed on the skin in the form of ointment; when the process of friction does not add to the sufferings of the patient, this will at all times be found a useful adjunct to the internal exhibition of the remedy; and where the deglutition is very much impeded, we are under the necessity of entirely depending upon it. Mercury, which in modern times has been regarded by some authors as a universal panacea for all complaints, has been employed in Tetanus, and, as we are informed, with the usual success; but it has not produced the same good effect in other hands. Wine or ardent spirits, taken in large quantities, has been recommended in Tetanus, and some cases are upon record where this plan has appeared to be successful; but upon the whole we think it is less effective than opium, and we percieve no motive for preferring it. Purgatives in this, as in all the Neuroses, are valuable adjuncts to our other remedies, but in Tetanus we are not to depend upon them as affording a radical means of cure.

Sect. XIII. *Colica. Colic.*

Perhaps the only idiopathic disease which can be considered as belonging to the next genus of the Spasmi, those which consist in an irregular action of the involuntary muscles, is Colica. Colic consists in pain of the bowels, especially characterized by a twisting sensation in the umbilical region, accompanied with spasmodic contraction of the abdominal muscles, and obstinate costiveness. There are many varieties of Colic, which are clearly referable to different exciting causes, but which nearly resemble each other in their symptoms: the peculiar state of the digestive organs, and of the biliary secretion; various articles of food, or merely an excessive quantity taken into the stomach; retention of the fæces; the application of cold and moisture to the feet; perhaps worms; and certain metallic poisons, particularly lead. It has been ascribed to a metastasis of gout from the extremities, and it has been supposed that the intestines were subject to Rheumatism; but whatever be the origin of the disease, it is probable that its proximate cause is always the same, an irregular contraction of the muscular fibres of some portion of the intestinal canal. When this state proceeds to a very violent degree, the peristaltic motion of the bowels is entirely inverted, and the fæces are even discharged by vomiting; occasionally the bowels have their action so much deranged, that one portion which is much contracted is forced into another which is less so, forming what has been called an intus-susception: the disease in this aggravated form has been termed Ileus, or the Iliac passion. There is no fever necessarily connected with Colic, and by this circumstance it may be distinguished from Enteritis; another diagnosis is, that in Enteritis the pain of the abdomen is increased by pressure, whereas in Colic it is perhaps rather relieved by this means; but although the diseases are essentially different from each other, yet Colic, if not speedily relieved, is liable to produce inflammation. On this account, when it is violent, we are frequently obliged to commence with blood-letting, which both obviates the subsequent tendency to the inflammatory state, and renders the exhibition of purgatives more effectual. The great object, however, is to procure the discharge from the bowels; but when the vomiting is severe, this is a point which it is often difficult to accomplish. For the most part it is dangerous to promote the tendency to vomiting, lest we should produce an inversion of the peristaltic motion of the intestines, yet sometimes the stomach is relieved by the free evacuation of its contents, and occasionally a single dose of opium is useful under these circumstances. We are, however, to place our main dependence upon purgatives, administered in frequently repeated doses, of such strength as the stomach will bear, and in the form which is least obnoxious by their bulk or their sensible qualities. The operation of purgatives is much promoted by injections, which should be as capacious as the parts will receive; and we may render them more active by mixing some cathartic ingredient with them.

The choice of the purgative depends upon a variety of circumstances, connected with the habits and constitution of the patient, for which it is not easy to lay down any general rules. Some practitioners place great confidence in calomel, either alone or combined with some drastic, as colocynth or scammony; where the stomach will retain it, and the disease is not too violent, oleum ricini is a safe and effectual remedy, and in most cases the neutral salts, especially the sulphate of magnesia, will be found useful adjuncts to the more powerful remedies. The patient is often much distressed with flatulence, for which he may obtain temporary relief by carminatives and stimulants; the latter, however, must always be given in small doses. When the bowels have been fully evacuated, the pain is generally relieved or much mitigated; but if this be not then the case, we may safely administer opium. Should there be much soreness of the abdomen, which is increased by pressure, indicating a tendency to inflammation of the peritonæum or the neighbouring parts, leeches or blisters will be proper; and in most cases we shall find relief from hot fomentations, or the warm bath. Persons who have suffered from Colic should be extremely cautious with respect to their diet, and should carefully guard against external cold, as it is found that a severe fit of the complaint always lays the foundation for subsequent returns of it, which may terminate either in acute inflammation, or may lead to some organic disease of the part, less rapid in its progress, but equally fatal in its ultimate result.

We have placed in this part of our system the disease of Tympanitis, an affection which is characterized by an enlargement of the abdomen, caused by a collection of air, either contained within the intestines, or diffused through the cavity of the peritonæum. Although it is generally described as a primary affection, we think there is much obscurity attached to it, and we are even disposed to doubt of its existence as more than a mere symptom of Dyspepsia, at least in that variety where the air is retained within the bowels. With respect to the other variety, it must necessarily be the result of a structural derangement of the part, as consequent upon some other disease, and is obviously incompatible with the existence of the patient for any great length of time. Many of the cases which have been described as Tympany we should be disposed to refer to Dropsy, and others to enlargement of the mesenteric glands, in both cases accompanied by flatulence, arising from the weakened state of the digestive organs, which usually attends this complaint.

Sect. XIV. *Pertussis. Hooping-cough.*

The third genus of the Spasmi contains the diseases that originate from irregular contractions of the semi-voluntary muscles, consisting almost exclusively of certain affections of the thorax, or the parts immediately connected with it. The diseases which may be regarded as primary, or of sufficient importance to claim our attention, are Tussis, Pertussis, Dyspnœa, Asthma, and Angina pectoris. Although we think that cases of cough occasionally occur, which cannot be referred to any more general affection, and which must be regarded as merely nervous, yet, as the disease is generally symptomatic, and when it is not so, may depend upon a variety of causes, which must necessarily render it almost impossible to lay down any general principles for its cure, we shall not attempt to give any farther account of it in this place, but shall proceed to the consideration of the next species, Pertussis. This is a peculiar kind of cough, which is characterized by several symptoms that point it out as a disease of a specific nature, a circumstance which is decidedly proved by the fact of its occurring only once during the life of each individual, and by its being propagated by contagion. It comes on in violent paroxysms of repeated short expirations, which are succeeded by a quick, deep inspiration, attended with a peculiar sound, that has obtained the name of hoop, or whoop, from which one of its popular names, that of Hooping-cough, is derived. The paroxysm is often terminated by vomiting, and induces a state of great debility and exhaustion, which, however, is so transient, that after the patient has been struggling for breath, and apparently almost expiring, in a few moments his functions resume their natural state, and he exhibits scarcely any traces of disease. As the complaint is contagious, and occurs once only during life, it necessarily happens that children are the most frequent subjects of it; but when it has not been gone through during childhood, every age seems to be equally liable to its attacks. There are few circumstances in pathology which are more difficult to explain than the manner in which a disease like Hooping-cough can prove contagious, which is not necessarily of a febrile nature, where there appears to be no matter generated which can be the medium of infection, and where there is nothing of the putrid or malignant nature, which is supposed to indicate a tendency to decomposition in the constituents of the body. As a point of practical importance, it has been questioned whether the contagion can be conveyed by a third person. We are not in possession of any facts which can enable us to decide positively on this subject, but we should suppose that this could not be the case, but that the breath of the patient must be actually inhaled in order to produce the disease. But, whatever conclusion we may form upon this point, we have sufficient evidence from our daily experience, that contagion is its most usual, if not its only cause. When a patient is under the influence of the complaint, the individual paroxysms are generally brought on by some obvious cause, as by muscular exertion, by taking food, or even by sudden mental emotions. At its commencement, the symptoms are scarcely to be distinguished from those of a common catarrhal cough, and three or four weeks often elapse before the characteristic marks of Pertussis make their appearance. The cough gradually becomes more severe, the expirations succeed each other more rapidly, and are followed by the sonorous inspiration, vomiting then comes on, and the patient falls into a febrile state, which seems to aggravate all the other symptoms. During the violent paroxysm of coughing, the passage of the blood through the lungs is so much impeded as to produce a deep suffusion of the face; and it frequently happens that some of the small arteries are ruptured, and that blood is discharged, mixed with the matter expectorated, or bursts out through the thin cuticle of the nose and mouth. When the disease has acquired its greatest degree of violence, it remains for some time stationary, and then declines. The period which it occupies in the whole process is very uncertain, and it is sometimes protracted for many months. Whenever it exists in its aggravated form it is accompanied with fever, and, although not necessarily of an inflammatory tendency, it often produces inflammation of the chest, and in this way proves fatal. In persons who are disposed by hereditary constitution to Phthisis, this complaint is frequently brought on by the Hooping-cough, and occasionally it seems to lay the foundation for a state of general marasmus or tabes, which ultimately proves fatal without the lungs being the actual seat of disease.

The cure of Pertussis is often tedious and embarrassing, and we have scarcely any general principles by which to direct us in our course. General bleeding is sometimes necessary at the commencement, and leeches may frequently be indicated by the pain or soreness of the chest; but it is not a disease in which copious depletion is necessary, or in which it appears to be attended with benefit. As the paroxysm is usually terminated by expectoration, so it has been the great object of the practitioner to administer medicines which may promote this process. Unfortunately, however, they are of very uncertain effect, and very dubious operation; and it not unfrequenly happens that greater injury is experienced by their heating or stimulating quality, than is compensated by any benefit to be derived from the discharge of mucus which they produce. Perhaps the most unexceptionable of this class are those that act as emetics; and, upon the whole, we think that the most effective treatment of Pertussis consists in giving ipecacuanha, so as to produce gentle vomiting once or twice daily. Antimony we think less proper, on account of its debilitating operation, an objectionable circumstance in a disease of such long continuance, and where the patients are often young and delicate. Diuretics have been prescribed in Hooping-cough; but we doubt whether they are of any use, while they are liable to the same objection with the expectorants. Next to emetics, perhaps the most generally useful remedies are blisters, which may be small, but frequently repeated. The disease is apt to degenerate into a chronic state, and, when all the inflammatory symptoms are gone, but the cough still remains violent, opium becomes admissible, and is often found very effectual; its good effects are increased by being combined with ipecacuanha. We have not much confidence in the tribe of antispasmodics which have been recommended in Hooping-cough. There is, however, one remedy, which, in the latter stage, is universally admitted to be very useful, a change of air; and it is remarkable, that it appears to be merely the circumstance of change, and not any quality in the air itself, as the same benefit is obtained, by taking the patient from the pure air of the country to the confined atmosphere of a crowded city.

Sect. XV. *Asthma.*

We not unfrequently meet with symptoms of simple Dyspnœa, which we find it difficult to refer to any other primary affection, yet it is so generally sympathetic, and its treatment depends so much upon the particular circumstances of the individual case, that we shall dismiss the farther consideration of it, and proceed to Asthma. Asthma is characterized by difficult and painful respiration, in which the breath is drawn at short intervals, and with what is termed a wheezing sound, attended with pain, and a sense of constriction in the chest, and a degree of cough. It occurs in paroxysms, which usually come on about midnight. It is frequently attended with a copious expectoration of mucus; but at times this discharge is not present; and accordingly the disease has been divided into the varieties of moist and dry. When the fit comes on in the night, the patient is affected for some hours before the accession with langour and drowsiness, and a degree of tightness in the chest, with some cough. These symptoms gradually increase until the paroxysm arrives at its greatest degree of violence, when, in three or four hours, it subsides spontaneously, leaving behind great debility and heaviness. It not unusually happens, that the same train of symptoms occur for several successive nights, when the disease becomes less violent, and for a time totally disappears. Generally, the patient is able to trace these accessions to some obvious exciting cause. Certain states of the atmosphere, as the air of large cities, fogs, or exhalations from damp ground, indigestion, or repletion of the stomach, and violent exercise, are the circumstances which we observe to operate the most powerfully. When once the disease has invaded the constitution, and gone through a complete set of paroxysms, we find that it is much more easily excited than at first; and at length it occurs when we are unable to assign any probable reason for it. The proximate cause of Asthma is obscure. The morbid contraction of the muscular fibres of the bronchiæ, which has been usually employed to account for it, we conceive to be a point of doubtful existence, and scarcely adequate to the effect. There are, however, many circumstances connected with the disease, which lead to the supposition that it is a primary affection of the nervous system. We not unfrequently observe individuals who pass a long life under the influence of Asthma, and apparently do not experience any considerable evil, except the pain and inconvenience arising from the actual presence of the disease; but there are many cases in which it terminates in Phthisis, Hydrothorax, chronic inflammation of the chest, enlargement of the heart, Aneurism, &c. by inducing a state of gradual decline, in which all the functions lose their due action, and ultimately proves fatal.

The obvious indications of cure in Asthma are, to moderate the violence of the paroxysm, and to prevent its recurrence, both of which we unfortunately find it very difficult to accomplish. Although the violence and frequency of the disease have rendered it an object of great attention to all practitioners, so that every one must have had much experience of the effect of remedies upon it, yet still we feel considerable uncertainty respecting their operation, or the degree of benefit which is to be expected from them. Depletion does not, upon the whole, seem to be useful; and although the sense of fulness about the chest, and the febrile state of the system, during the paroxysm, might seem to indicate bleeding, yet we believe it has not been productive of the expected relief. Nor is the good effect of purgatives so evident as in many of the Neuroses; and we may make the same remark with respect to blisters, which, in affections of the chest, are usually resorted to with much advantage. The fit frequently terminates in expectoration; yet it would not appear that any decided advantage is obtained by the administration of what are termed expectorants, and even emetics are said to have failed in shortening the paroxysm, while the efforts to evacuate the contents of the stomach have materially added to the distress of the patient. Very favourable reports have been made of some of the sedatives or narcotics, especially tobacco and stramonium; but it does not appear that they are equally successful in all cases, and where they have proved efficacious when first employed, they have afterwards appeared to lose their power; the same remarks may be made respecting opium, which, in moderate doses, has occasionally proved useful, but perhaps has more frequently failed. The inhalation of the steams of hot water is a palliative, which may be safely employed; and as the patient is usually affected with flatulence and eructations, we may obtain some relief from magnesia and the carbonated alkalies. Nor are the means which we possess for preventing the recurrence of the fit much more certain than those for shortening its duration. When Asthma is connected with any constitutional malady, it will be proper to endeavour to remove this latter, or if possible to obviate its exciting cause; and we must carefully watch the state of all the functions, more particularly of the stomach and bowels, and endeavour to restore their healthy action when deranged, but beyond this we fear that our efforts will be nearly unavailing. Like other nervous diseases, Asthma is supposed to degenerate into that chronic state, in which the paroxysms occur, although the exciting cause is no longer supposed to exist, as if by the force of habit. It may indeed be doubted how far this idea is well founded, but we certainly observe instances where the complaint appears to be relieved by a change of situation, or a complete alteration in the mode of life and occupations of the patient.

Sect. XVI. *Angina pectoris.*

This disease is characterized by sudden attacks of acute pain in the lower part of the chest, which shoots up the shoulder and extends down the arm of the left side: they are attended with laborious respiration and an apprehension of immediate suffocation, while there is frequently an irregular action of the sanguiferous system, or even a temporary suspension of the motion of the heart. The paroxysms are of short duration, and come on at uncertain intervals, while, at other times, the patient is nearly in his ordinary state of health, until the disease, by frequent repetition, gradually undermines the constitution, and the attacks become more and more violent, until at length one of them proves fatal. Their accession may generally be traced to some obvious exciting cause, of which the most frequent is walking briskly up a steep ascent, and this is especially the case, when the stomach is in a state of repletion; mental emotions are also among the exciting causes of the paroxysms; and when the disease exists in its violent form, it may be induced by almost any muscular exertion, however slight, or even without any obvious cause. It is not a little remarkable, that until about the middle of the last century, this affection, although so severe and well marked in its symptoms, and not of very rare occurrence, should have passed unnoticed as a distinct disease. Latterly, however, its phenomena have been accurately described, and its nature carefully examined; and we learn, as the result of this examination, that it is generally connected with an ossification of some of the valves or orifices of the heart. Although this change of structure has not been detected in every instance, yet we may conceive of other circumstances producing a similar effect upon the transmission of the blood through the heart, and may therefore conclude that its proximate cause is always to be referred to some circumstance connected with the mechanism of the circulation. With respect to the cure of the disease, our hopes of relief must depend very much upon the period when it comes under our care; in the latter stages, where ossification has actually taken place, we can do little more than use all our endeavours to obviate the exciting causes; but in the earlier stages, when there is no morbid change of structure, very decided benefit has been obtained by large caustic issues. Our attention is forcibly directed to the situation of the patient during the paroxysm, which is not only attended with exquisite suffering, but is sometimes immediately fatal. Yet it is doubtful whether any thing, except rest in the horizontal posture, will be of service in shortening the fit, or mitigating its violence. It is of great importance to preserve the stomach and bowels in a healthy condition, by a strict attention to diet and purgatives, and we must avoid all undue action of either the bodily or the mental powers. It does not appear that opium, or any of the antispasmodics, afford relief in this complaint, and we conceive that the employment of stimulants or excitants might be positively injurious.*

CHAP. III.

Vesaniæ. Diseases of the Mental Faculties.

We have arranged the idiopathic affections of the mental faculties in a separate class, under the denomination of Vesaniæ; for although we may conceive, that they always depend upon some derangement of the brain, the instrument by which they are exercised, yet their phenomena are so peculiar, and the relation which exists between the corporeal and the intellectual part of

* The text seems most partial to the theory of Angina Pectoris, maintained by Dr. Parry; it is unquestionably the most popular one, though many circumstances might be mentioned, which strongly militate against it. The writer of this note is of opinion, that Angina Pectoris, for the most part, proceeds from an inordinate fulness of the vascular system, more especially from a disproportionate accumulation in the heart and larger vessels. The great accumulations of fat, the effusion of water in the thorax and pericardium, the distended state of the vessels, and even the earthy deposits occasionally met with in the valves and vessels of the heart, may be considered the effects of such plethora. This pathological view is strengthened by observing that the persons most liable to attacks of this disease, are those in advanced life, of corpulent and gouty habits, with short necks The attacks of this disorder occur most commonly in the winter and spring; the patient, moreover, often suffers from spontaneous discharges of blood in different parts of the body, anxious and oppressive breathing, numbness of the extremities, giddiness, and other symptoms indicative of an overloaded state of the blood-vessels. Dissections lead to the same conclusion. The mode of treatment is pointed out in the circumstances above mentioned; copious depletion by the lancet, and active cathartics must be had recourse to; issues have also been followed by beneficial effects; and for the removal of the spasm, palpitation of the heart, and coldness of the extremities, æther, volatile alkali, and other diffusible stimuli, are to be exhibited. Opiates, after blood-letting, are often used with advantage. Warm bathing and friction of the extremities, are also useful. A due regard to diet and regimen, are of great consequence in preventing the return of the disease.

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our frame is so obscure, as to be altogether beyond our comprehension, at the same time that the two kinds of diseases require a totally different method of treatment. This part of medicine has unfortunately been much embarrassed, by the application of what has been termed metaphysical reasoning, but which has, in fact, consisted of the use of certain ill-defined and unmeaning phrases; the effect of which has often been, to produce the same confusion in the mind of the reader, which must have existed in that of the writer. Another, and perhaps a still greater source of difficulty, in every thing that respects the pathology of insanity, has arisen from an unreasonable prejudice that has attached to certain opinions respecting the nature of the intellectual faculties, in consequence of their being supposed to be adverse to religion and morals. Respecting the real merits of the doctrine of materialism, the one here alluded to, we do not pretend to decide; but we consider it a fair and legitimate object of philosophical inquiry, and it is one which is intimately connected with any hypothesis that we may form respecting the nature of the human powers, and their relation to the external world. It has not, however, any immediate or necessary connexion with pathology; for, whatever may be our opinion respecting the cause on which the faculties ultimately depend, we know that they are always exercised through the intervention of the brain; and with respect to the subject of insanity, it becomes an important practical question, whether the structural derangement of this organ corresponds, or is proportional to the mental disease. On this point, we are disposed to decide in the negative; for although we are informed, from high authority, that whenever the brain has been accurately examined in cases of insanity, some disease in its structure may be detected, we are of opinion, that it frequently bears no proportion to the violence of the complaint, while, on the contrary, we have equally numerous cases of great destruction, or disorganization of the brain, without a corresponding injury of the faculties.

Insanity has been divided into different genera and species; but we think it sufficient to consider it under two forms only—that where the faculties are prevented, and that where they are, in a greater or less degree, destroyed; the first constituting Mania, the latter Amentia. Although the phenomena of Mania are familiar to every one, both professional and unprofessional, yet there is perhaps no disease which it is so difficult to define, and the existence of which it is often so difficult to ascertain. The question of Insanity frequently comes to be discussed in courts of law, and we perpetually observe men of the most acute discernment and extensive information, differ in their opinion upon particular cases that are subjected to their judgment. This, in fact, depends upon a circumstance, which may appear sufficiently mortifying, that there are really no exact limits by which insanity can be separated from that state of mind which is deemed sufficiently sound to enable a person to transact the usual affairs of life. The most lamentable weakness of judgment, and the most singular perversion of the reasoning powers, unless exercised in a certain way, which is dangerous to the existence of the patient, or those about him, pass by as not differing from the condition of the rest of mankind, except in degree; and it is frequently from some accidental circumstance connected with it, that it acquires the name of disease, and subjects the patient to restraint and confinement. It is indeed usually more from the degree of the affection than any thing specific in its nature, that our judgment is ultimately formed, and rather by a detailed history of the circumstances of the case, and by comparing the present with the former state of the patient, than by any single diagnostic circumstance, that we finally decide.

There are several varieties of mental derangement which it is important to attend to; the first and most equivocal kind is that which consists in extreme caprice, or irritability of temper, and is the most difficult to discriminate from a sound state of the mind, as passing into it by shades that are absolutely insensible. Another variety is, where the disposition and habits undergo a complete change, which is independent of external circumstances, or of moral causes; a state that is often characterized by the mind becoming exclusively devoted to some one object, which is at one time of the most important, and at another of the most trifling nature, but still not decidedly beyond the limits of what may be considered as the result of rational deduction. From these we proceed to that variety of the disease where there is a complete perversion on one or two points; while on every other subject the mind retains its full powers; and from this we glide insensibly into that deplorable condition of the human nature, where the understanding is entirely deranged—where the individual is unconscious of the effect of his actions, and almost insensible to the impressions of surrounding objects upon the organs of sense.

Besides the difficulty which so frequently exists respecting the actual presence of the disease, other equally embarrassing points come under the cognizance of the physician. The first of these respects the question, whether the state of the patient requires his being removed from his friends, and whether the symptoms are such as to render him a proper inmate of a public asylum. As a general rule, we conceive it to be clearly established, that the patient is always best managed by those whose business it is to take care of the insane; and in a great majority of instances it seems that recovery is more promoted by the patient being removed from his accustomed abode, than by any plan which can be pursued, while he is surrounded by the scenes with which he had been previously familiar. The unpleasant association which must attach to a residence in a lunatic asylum is, no doubt, an objection to the removal, and formerly, while these institutions were regarded rather as places for coercion than for medical treatment, every one must have felt anxious to avoid the painful necessity of subjecting a friend or a relation to their cruel discipline. The enlightened spirit of the present age has, however, happily reformed the greatest part, if not the whole, of this system, and has thus not only rescued a large portion of our fellow-creatures from unmerited suffering, but has afforded them the prospect of a restoration to the blessings of health and the comforts of society.

In this brief sketch, we shall not enter into any detail respecting the means of curing insanity. One of our first objects must be to inquire into the exciting cause, and if possible to remove it; we are next to examine the condition of the system generally, and of the circulation in particular, whether there be any deviation from the healthy state, which we may have it in our power to relieve. Beyond this we have perhaps no general principles on which to proceed. The digestive organs are always to be carefully attended to, and in females we are minutely to watch the state of the uterine functions. The employment of the various means of depletion is to be regulated entirely by circumstances, and the same remark may be made as to the use of stimulants or sedatives; but, for the most part, the cure cannot be accomplished by the mere use of medicine, independent of general management or moral discipline. Every thing concurs to prove, that violence and harshness are as useless as they are inhuman; that constraint is only so far proper, as to prevent the patient from injuring himself, or those around him; that we must regard the insane as entitled to all the privileges of humanity; and that, when the reasoning powers are not too far perverted, they may, in a majority of cases, be restored, by treating the patient with a due mixture of gentleness and firmness, and by occupying him with such pursuits as may engage his ideas without harassing them. The cure of Amentia is more hopeless than that of Mania; it more frequently depends upon an obvious structural affection of the brain, and is more frequently either connate, or the effect of some irremediable injury. The treatment is the same for both the species, indeed there is no exact limit between them; so that, in the same patient, they often make their appearance at different periods of the complaint, or glide insensibly into each other. It may be observed, that the prognosis is more unfavourable when the affection is hereditary, or when it comes on without any obvious cause; while, on the contrary, the cases which consist of what is termed over-excitement, or violent delirium, are more easily relieved than such as seem to depend upon mere weakness, proceeding from a diminution rather than excess of nervous energy. With respect to the operation of particular remedies in insanity, we may remark, that bleeding is not to be employed, except there be some indication of its use from the state of the circulation. It does not appear to have any specific effect over the disease; and nothing can be more disgraceful to the profession, than the indiscriminate manner in which it was practised, until very lately, even in our first public establishments. The same observation may be made respecting all the other evacuations, which are only to be had recourse to when there is something in the state of the functions which seems particularly to call for their employment. Opium, camphor, digitalis, have each had their advocates, as well as the warm bath, the application of cold under various forms, and different kinds of mechanical exercises; but it may be doubted whether any very decided benefit ought to be expected from them, or at least more than what can be supposed to depend upon their effect in promoting the state of the general health. Many of the alleged cures of insanity have, no doubt, been accomplished through the medium of the imagination, where the complaint was only partial, so as to leave the patient in a situation to be conscious of what was passing around him; and, in some of the protracted cases, it must be attributed merely to the spontaneous effects of the system, inducing a salutary change in the functions, independently, or perhaps even in opposition to the means that were employed for the cure. See Insanity.

CHAP. IV.

Paratrepses.

Sect. I. *Dyspepsia. Indigestion.*

We now come to our fourth class of diseases, those which we have named Paratrepses, including the morbid affections that are concerned in the function of nutrition, of which the most important are the stomach, the intestinal canal, the liver, and the absorbent system. The first of the four orders into which we divide this class, consists of diseases of the stomach and its appendages, of which we begin by an account of Dyspepsia. Dyspepsia, or Indigestion, as it is popularly termed, is a complaint that is infinitely diversified in its symptoms, and depends upon a great variety of causes, some connected with the structure and composition of the parts, and others with their functions, independent of any visible alteration. It is a complaint which does not run through any regular course, or observe any uniform progress, but consists in a number of morbid actions, which succeed or accompany each other, as it appears, merely from incidental circumstances. Among the most common symptoms of Dyspepsia, we may enumerate the following: loss of appetite, or sometimes the contrary state of an acute feeling of hunger, while the stomach is incapable of digesting the food that has been received into it, nausea, vomiting, pain of the stomach, costiveness, or the opposite state of diarrhœa, morbid condition of the fæcal discharges, flatulence, heartburn, eructation, head-ach, and a furred appearance of the tongue; a circumstance which affords the practitioner one of the most certain indications of the state of the patient, and enables him to form his prognosis. The disease is not attended with fever, nor is the pulse necessarily affected, until it be so from the weakness which is induced when it is of long standing, and when the powers of the body begin to fail from the deficiency of nourishment. It is observed, that the mental faculties are much connected with, or influenced by, the condition of the stomach; so that the same individual, who possesses the most active and cheerful disposition while the digestive organs are free from oppression, after a full meal becomes languid, melancholic, and desponding. The exciting causes of Dyspepsia are as various as the aspects which the disease assumes. Every other disease, which in any way influences the state of the general health, may induce Dyspepsia; all violent mental emotions, especially those of a depressing kind; sedentary habits, or exercise carried to the length of exhaustion; and, what is the most frequent cause, and the one which produces the most urgent and distressing symptoms, a luxurious diet, or merely too great repletion; and especially the excessive use of fermented or spiritous liquors. The habitual employment of opium or tobacco seems to act very unfavourably upon the digestive organs; and, in short, whatever may be supposed either to diminish the vital powers, or to produce their irregular action, frequently manifests its injurious effects through the medium of the stomach. Another class of causes which impair the digestion, are those that consist in some structural disease of the various chylopoetic viscera, as chronic inflammation, contraction, or scirrhus of the stomach itself, which usually occurs about the pylorus; affections of the spleen and pancreas; and whatever impedes the due secretion of the bile, or its discharge into the alimentary canal.

The indications of cure to be observed in Dyspepsia are sufficiently obvious, but the accomplishment of them is often very difficult; and perhaps, in a majority of cases, we are rather to practise with a view to obviate particular symptoms, than in prosecution of any general principles. Our first object must be to ascertain, if possible, whether there be any structural disease of the stomach or the digestive organs, a circumstance which must materially influence our treatment, and still more our prognosis; for while we may hope to relieve the most obstinate dyspeptic symptoms, as long as the structure of the part is unimpaired, so our prospect of success must always be very small on the contrary supposition. In this latter case, the disease is to be regarded as entirely symptomatic, and, until the primary affection be removed, not only would most of the remedies that are proper for Dyspepsia be useless, but probably even injurious. When we have reason to suppose that the affection of the stomach is altogether independent of the structural disease, our first object is to inquire into the habits and modes of life of the patient, and especially into the nature of the diet; and, for the most part, we shall find that, by a proper regulation of these points, the most urgent symptoms may be relieved even more effectually than by the exhibition of the most powerful medicines. Yet painful and distressing as the complaint is, so much so as to destroy all the comforts of life, and even to render existence itself a burden, so inveterate are the habits of self-indulgence, and so unable is the patient to resist the calls of a pampered appetite, craving for its accustomed gratifications, that we too frequently find all our admonitions to be in vain, and our advice to be totally neglected. With respect to other remedies, the numbers that have been employed, and the various forms in which they have been administered, to accommodate the taste or the caprice of the patient, are almost infinite; but we may arrange them under the three heads of evacuants, stomachics, and tonics. It generally happens that the intestines are either torpid or in an unnatural state, and there is perhaps no instance of Dyspepsia, of all the numbers that fall under our care, in which we shall not find it highly beneficial to commence with active purgatives. They will be frequently found to supersede the whole tribe of carminatives, antispasmodics and antacids, which have been so liberally prescribed in this complaint, and will lay the best foundation for the subsequent use of stomachics and tonics. It would not be consistent with the nature of this treatise to enter into any account of the particular medicines, or combinations of them, which may be adapted to the various symptoms or conditions of the disease, but we generally think it desirable to employ them in a simple form and in small doses, and rather to rely upon a change in the external circumstances, which may be conceived likely to promote the general health, than upon the administration of any particular article of the materia medica. Country air and exercise, temperance in diet, avoiding the oppressive cares of business; and, we may add, as what is scarcely less necessary, the unreasonable pursuits of pleasure, are the grand remedies for Dyspepsia; and we conceive that no one who has given them a full trial, and has experienced the relief which is obtained from them, will be disposed to relapse into those luxurious habits, from which it is so difficult, in the first instance, to wean the patient.

Among the remedies which are of the most decided benefit in Dyspepsia, next to purgatives, and after they have performed their full effect, we may place the tribe of stomachics, consisting of the simple bitters, of which perhaps the most efficient are gentian and quassia; and, of those substances which seem to consist essentially of a bitter and an aromatic, of which we should select calomba and cusparia, as the most generally useful. Of the tonics, perhaps the most powerful in strengthening the digestive powers, is the union of one of the stomachics with iron: for simple pain of the stomach, the oxide of bismuth has been recommended upon high authority; but we apprehend that the complaint in which this medicine has been found so efficacious, is rather to be considered as a species of Autalgia, than the pain which is symptomatic of Dyspepsia. A very valuable medicine, and one which is applicable to every form of the disease, is the carbonate of potash; it appears not only to neutralize any acid which may exist in the stomach, but so to regulate the process of digestion, as to prevent its formation; and it has been found, that it may be taken for months or years if necessary, without producing any kind of injurious effect. An irregular state of the alimentary canal is almost a constant attendant upon Dyspepsia, and although it generally produces constipation, it occasionally manifests itself in the opposite state of diarrhœa. Except in very protracted cases, or where there is reason to suspect some structural derangement, this symptom generally yields to a cautious exhibition of purgatives, together with a due attention to the state of the diet; and without any specific treatment the bowels acquire their proper tone, as the system returns to its healthy state. Astringents we conceive to be seldom necessary, and for the most part injurious; diaphoretics, particularly opium combined with ipecacuanha, are frequently found beneficial, and this may be regarded as the best form of giving opium, where pain or any other symptom indicates its employment; it must always be preceded or accompanied by mild purgatives.

Sect. II. *Diabetes.*

Next to Dyspepsia we have placed Pyrosis and Pica in our list of diseases, which depend upon a defect of the digestive organs; the former of them consisting in the eructation of a watery fluid from the stomach, attended with pain, heart-burn, and flatulence; the latter in a species of perverted appetite, by which the patient is seized with an almost unconquerable desire of eating indigestible substances, that are not properly articles of food. Although these are usually considered by systematic nosologists to be distinct diseases, and occasionally occur almost unconnected with any other symptoms, yet we are induced to regard them as mere modifications of Dyspepsia; and, with respect to their treatment, we have little to offer in the way of general principles that has not been stated in the preceding section. We shall merely remark that Pyrosis is generally supposed to originate from the habitual use of an indigestible diet, which must of course be attended to in the cure, and that Pica is commonly found to be connected with a torpid state of the uterine system, as well as of the digestive organs.

The next disease which we have placed in this division is Diabetes, an affection of a very peculiar nature, and which, both with respect to its origin, its proximate cause, and its treatment, has given rise to much controversy. Its most remarkable symptoms are, a great increase in the quantity of urine, a voracious appetite, a stoppage of the cutaneous perspiration, thirst, emaciation, and great muscular debility. The urine is not only prodigiously increased in its quantity, but likewise has its composition completely changed; the substance named urea, which it contains in the healthy state, is entirely removed, or exists in very small proportion, while in its stead we find a large quantity of a body possessing the physical and chemical properties of sugar. Whether diabetic differs essentially from vegetable sugar, is to be regarded more as a chemical question, than as what in any respect influences either our pathology or our practice; and it has been a subject of controversy whether there be a proper Diabetes insipidus, that is, a disease attended with the increased discharge of urine, the voracious appetite, and the morbid state of the skin, but where the urine does not contain sugar. There is much obscurity respecting the origin of Diabetes; it has been attributed to improper diet, to the use of spiritous liquors, to large quantities of watery fluids, to exposure to cold during perspiration, to violent exercise, and, in short, to any thing which might be supposed likely to weaken the system generally, or the digestive organs in particular. It does not, however, appear that any of these circumstances so commonly precede the disease, as to entitle it to be regarded as the cause, although many of them may contribute to aggravate it, or bring it into action, when the foundation is laid in the constitution. The proximate has been no less the subject of controversy than the exciting cause, and on this point two hypotheses have divided the opinions of pathologists; some have ascribed it to a primary affection of the stomach and the function of assimilation, and others to a primary disease of the kidney. Upon the whole, we conceive that the former is by far the most probable supposition; for although the examination of the body after death has detected a morbid state of the kidneys, this we should ascribe to the great alteration in the quantity and quality of the fluid which passes through them, rather than have recourse to the idea, that any change in the secreting vessels of the kidney could produce such a complete perversion of the actions of every part of the system.

Diabetes has, of late, occupied an unusual share of the attention of medical men, in consequence of the circumstances connected with its treatment appearing to coincide with some pathological doctrines which were fashionable a few years ago. The remarkable change in the chemical condition of the urine, by which a compound, consisting of hydrogen and carbon is substituted for one into which azote enters as a principal ingredient, led to the idea, that by excluding these elements, as much as possible, from the diet of the patient, the morbid state of the fluid might be prevented or corrected. It was accordingly found that, by employing a complete animal diet, the sugar was no longer produced; and it was announced that, by strictly adhering to this regimen, the disease had been completely cured. Subsequent experience has not, however, confirmed these favourable reports, for although, while the hydrogen and carbon are no longer present in the digestive organs, the sugar can be no longer generated, yet the diseased action seems to remain without alteration, so that, upon the least deviation from the animal diet, the saccharine urine is reproduced, at the same time that the patient remains nearly in his former state of debility, without any considerable abatement of the other symptoms; so that, although the progress of the complaint be retarded, it does not appear that it ever has, by this means, been ultimately counteracted. A very different mode of treatment has been since proposed, and even adopted in Diabetes. Notwithstanding the apparent failure of the muscular powers, and the different circumstances indicating the extreme of debility, very copious bleedings have been employed, and if not with much benefit, at least without that aggravation of the disease which might have been apprehended. The old method of treating the complaint, and the one which is still often had recourse to, is by astringents of various kinds, to which opium is often conjoined; and of the efficacy of this practice we have many flattering accounts, but, from its total failure on other occasions, we suspect that the alleged cases have either not been proper Diabetes, or that the medical attendants have hastily caught at some flattering appearances of amendment, and mistaken them for a radical cure. Upon the whole, we believe that where the urine was in large quantity and highly saccharine, where Bulimia existed in any considerable degree, and where the cutaneous perspiration was abolished, no cure has ever been accomplished. With respect to the treatment which may afford the best chance of success, or which may possibly remove the complaint in its incipient state, we should recommend that a moderate bleeding be premised, and that a diet be employed, of which vegetable matter should form only a small proportion; at the same time we may administer vegetable tonics, and may endeavour to restore the natural action of the skin by diaphoretics and the warm bath.*

Sect. III. *Podagra. Gout.*

Gout may be characterized as a disease which recurs in paroxysms, consisting essentially in the pain of one or more of the smaller joints of the hands or feet, most commonly of the great toe, which is attended with fever, and terminates in redness and swelling of the

* The weight of testimony is unquestionably in favour of the theory that Diabetes primarily depends on a diseased action of the digestive organs, or a want of tone in the assimilating powers of the system; the kidneys are secondarily affected. Of the causes which induce an impaired state of the stomach, intemperance in the use of ardent drinks is the most common. The most successful treatment of Diabetes is that originally proposed by Sydenham; the use of animal food and abstinence from vegetable substances. Ferriar judiciously prescribes, besides animal food, various tonics, as bark, bitters, chalybeates, &c. (See Med. Hist. and Reflect. vol. iv.) In a late case, the writer has removed the disease by the use of animal food alone.

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part; the local affection is preceded by a state of general indisposition, and especially by various dyspeptic symptoms; and we usually find that, when the inflammation is established in the extremities, the stomach becomes relieved. The paroxysms come on at uncertain intervals, and frequently without any obvious exciting cause; but it is generally connected with an hereditary predisposition, and is scarcely ever met with except among persons in the higher ranks of life; and for the most part, when not hereditary, may be clearly traced to habits of luxury and self-indulgence. When Gout exists in a well marked form, there is no difficulty in distinguishing it from all other affections; it is easily recognized by the state of the stomach, the part which is affected, and the nature of the predisposing and exciting cause; but in its more irregular forms, it is apt to be confounded with Rheumatism, and it appears, indeed, that the two diseases are sometimes combined in the same patient. In those who are predisposed to Gout, it may be excited by any thing which produces an increased action in the part, as by excessive exercise, by a strain, or a bruise; but in those who inherit the disease, or who have once suffered severely from it, we often find it impossible to detect any assignable cause for the paroxysm. The fact that Gout never attacks the poor, while even a considerable proportion of the wealthy are more or less subject to it, is known to every one, and has necessarily given rise to much speculation respecting both its predisposing and its proximate cause. It is not very easy to determine to which of the circumstances that attach to the condition of the rich its production is to be attributed; mere excess in eating, although it produces stomach complaints, does not generate that specific state of the digestive organs which gives rise to Gout, nor do we find that the abuse of fermented or spirituous liquors, which is so common among the lower classes, subjects them to this complaint. It would appear that it depends upon the combined operation of luxurious habits of various kinds, of which, indulgence in the gratifications of the table, and the want of a due quantity of bodily exercise, are probably the most important.

Besides the regular forms of the disease, where it occurs in paroxysms, that alternate with, or succeed to complaints of the stomach, and leave the patient in perfect health during the intervals, there are other varieties of the disease, in some of which the different stages exhibit considerable irregularity, both with respect to their degree of violence, and the order of their succession; in one of these, which is called retrocedent, or repelled Gout, after the disease has settled upon the joints of the extremities, it suddenly leaves the part, and attacks some of the internal viscera, the brain, the lungs, the heart, or the stomach; and, if not relieved by the appropriate remedies, may suddenly prove fatal, by preventing these organs from performing their ordinary functions. The regular Gout is not a disease which is usually considered as productive of danger to the life of the patient; but it materially impairs his comforts and utility, for the fits generally increase upon him, both in their violence and their duration, so that at length he is doomed to pass a considerable part of his time under their influence, while the joints, by the repeated attacks of inflammation, become distorted, or nearly immoveable. The irregular Gout, although productive of less urgent symptoms, and of little or no injury to the joints, has the effect of imbittering the life of the patient, by an almost constant state of indisposition; and it has a peculiar tendency to induce a distressing lowness of spirits, and a feeling of despondency, which are more intolerable than acute pain.

The phenomena of Gout were formerly regarded as affording the most direct evidence of the theory of the humoral pathologists, in which a morbific matter exists in the fluids, is capable of being conveyed from one part of the body to another, and manifesting its presence in them by its appropriate symptoms. Palpable, however, as this conclusion was conceived to be, the modern pathologists have denied the existence of this morbific matter, of which it has been said that no evidence exists, except what is derived from the symptoms of the disease; and these, they have asserted, might be better explained upon other principles. The researches of the modern chemists have, however, given some plausibility to the doctrine of the humoralists, by discovering that gouty urine contains an unusually large proportion of lithic acid; and as the same substance has been found exuding from the joints, in combination with soda, it would seem to follow, that the general mass of the circulating fluids are impregnated with it. But although the fact must be interesting, both in a pathological and a practical point of view, it cannot be considered as throwing much light upon the proximate cause of Gout, as we have still to inquire how the presence of the lithic acid can produce the peculiar affection of the stomach, why it is transferred from the stomach to the joints, why it particularly attacks the small joints of the extremities, why the general and local symptoms alternate with each other, and, in short, what connexion or relation it bears to the ordinary symptoms of the disease.

The treatment of Gout has varied very much at different times, according to the prevalence of particular medical theories, or the pathological doctrines that have been entertained respecting the nature of the complaint. While all diseases were regarded as salutary efforts of nature, the paroxysm of Gout was considered rather as a curative operation, which was to be induced or promoted by the practitioner, than as a morbid condition of the system which it was his business to remove. Accordingly, all our attempts were more calculated to increase, than to diminish the inflammation of the joints, by the application of warmth, and by the use of stimulating diet and medicines; and even during the intervals of the fits, so great was the apprehension of the mischief that might arise from checking the efforts of the *vis medicatrix*, that nothing was attempted more than a mere palliative plan, which was generally altogether inert. Of late, however, we have ventured upon a more active practice, and we have not hesitated to oppose the regular progress of the disease, or even to counteract the natural actions of the system. We administer brisk purgatives to clear the alimentary canal, we attempt to moderate the inflammation of the joints, if not by the application of cold, at least by the abstraction of heat; and we occasionally employ bleeding, either general or topical, and enjoin the strict antiphlogistic regimen. To what extent this plan is to be pursued, must be left to the discretion of the practitioner, as determined by the urgency of the case; while we have ample evidence of its safety, when judiciously employed, we are to bear in mind that the inflammation of Gout is of a specific kind, and that the immediate danger of the disease consists in its being repelled from the extremities to the internal viscera. After we have carried the depleting system as far as is thought proper or necessary, opium, either alone, or in combination with ipecacuanha, will be found useful for removing irritation, and bringing back the functions into their ordinary state. When the fever and inflammation have subsided, we shall probably find a course of bitters and stomachics necessary to strengthen the digestive organs, and to prevent the recurrence of that state which lays the foundation for future attacks of the disease. But this object, which is even of greater importance than the cure of the individual paroxysm, is to be attempted more by regulating the habits of the patient, than by the employment of any particular article of the materia medica; provided the constitution be not too much impaired, and the alteration be not too hastily adopted, we find that, by exchanging a life of gluttony and indulgence for one of temperance and activity, we are generally able o accomplish the desired effect. Simple however, as this plan may appear, it is but seldom that the practitioner is able to put it into execution; for so wedded are the patients to t eir accustomed indulgencies, that they shut theirs ears to the salutary counsels of their medical attendants, and voluntarily resign themselves to pain and disease, in preference to health and comfort, when they are to be purchased by the renunciation of their luxurious habits.

An important circumstance yet remains to be noticed respecting the cure of Gout, the discovery of a medicine which is supposed to have a specific effect upon the disease, so as to remove it by a kind of operation which we cannot refer to any general principles. The medicine was introduced into practice in the form of a secret recipe, but it appears to be ascertained that its essential ingredient is the colchicum autumnale. This is one of those substances which, when taken in a large quantity, prove highly deleterious; but in moderate doses, it may be taken without danger, and usually operates by producing an evacuation either from the bowels, the kidney, or the skin. It affords almost a unique example of a remedy being introduced into practice under an empirical form, which maintained its reputation after its composition had been detected; for we seem to be in possession of the most unequivocal evidence of its power, both in preventing and removing the gouty paroxysm. Sometimes the salutary effect ensues without any sensible operation, but generally the benefit is more apparent, and there is supposed to be less danger of any deleterious action on the vital powers, when some kind of evacuation has taken place. Cases have occurred, in which, by giving the medicine in too large a quantity, or in an improper state of the system, it appears to have produced almost the immediate destruction of life; but by using the proper precautions, we conceive that the colchicum may be administered with safety and advantage.*

Sect. IV. *Cachexiæ. Scrofula.*

In the order of the Cachexiæ we shall find some of the most formidable diseases which attack the human frame, both from the extent of the mischief which they occasion, and the little power which our remedies possess over them. The first that we shall notice is Scrofula, to which, as indicating its pre-eminently baneful influence, the name of *evil* has been popularly applied. The term scrofula has, we think, heen used in too vague a manner, so as to include a variety of anomalous affec-

* This section on Gout deserves great consideration. The writer of this note is induced to insert here his views on this disease, though previously before the public. 1st, Gout is not an hereditary disease, in the sense in which it is usually considered; it is only hereditary as far as fortune, and its attendants, ease, luxury, habits of intemperance both in eating and drinking, and that predisposition which arises from a strong and vigorous constitution, are hereditary. 2d, Gout takes place for the most part in the sanguine temperament, in the plethoric habit of body, and is exclusively an inflammatory disease of the whole system, as well as of the part affected. 3d, Its associate or vicarious diseases, Apoplexy, Palsy, Angina Pectoris, Asthma, habitual Catarrh, Eruptions on the Skin, Obstructed Viscera, and Dropsy, arise from the same habit of body, and from the same causes. 4th, The deposits of saline or earthy matter, which take place upon the joints, in Gout and Rheumatism, in the kidneys and bladder, occasioning Stone and Gravel, in the brain of apoplectics, in the arteries of persons advanced in life, in the coronary vessels and valves of the heart, have the same common origin, and these extravasations are usually the effects of an overloaded state of the blood-vessels. 5th, Although the same earthy or saline materials exist in the blood in a state of health, and are constantly passing off in our excretions, they are in no instance the cause of Gout; but when deposited upon the joint, in that disease, or upon other parts of the body, such deposits are the effects of plethora, the parent of both. 6th, The *predisposing* causes of Gout are, the excessive use of wine, ardent spirits, animal food, the condiments of the table, and the neglect of the exercise necessary to counteract their effects upon the constitution; while the check of the excretions by the cold of autumn and winter, or the sudden impetus given to the circulation by the returning spring, proves the most usual exciting cause of this disease. Hence we find that Gout, like Rheumatism, and other inflammatory diseases, the attendants upon autumn, winter, and spring, are but rarely to be met with in the summer season, when our diet consists of a large proportion of vegetable food, and the excretions, especially by the surface, are most abundant: hence, too, it is observed, that persons who are remarkable for their excessive discharges by the skin are rarely the subjects of Gout, even though the usual causes of this disease are, at the same time, indulged in to a great degree. 7th, As the causes of Gout are *intemperance* and *indolence*, the best means of preventing this disorder may be summed up in their immediate antidotes, *temperance* and *exercise:* but where the patient has not resolution enough to withstand the temptations of the table, and is unable to take the necessary exercise, the occasional evacuations by the lancet, and other means of diminishing the fulness and excitement of the vessels, should be employed. 8th, The most effectual means of removing the inflammatory action attendant upon the first stage of the paroxysm of Gout, consist in depletion by the *lancet, cathartics*, and such remedies as operate by restoring the excretions from the surface of the body, the physician paying due regard, in the use of these means, to the constitution of the patient, his time of life, and season of the year In correspondence with the use of these remedies, both the diet and regimen of the patient should be simple, and strictly antiphlogistic. 9th, During the febrile stage of the paroxysm, the part or parts affected should be lightly covered with soft flannel, or carded cotton, for the purpose of soothing the existing irritation, and of promoting a perspiration from their surface: the practice, however, of loading the limb with the accustomed strata of flannel, and thereby of adding to the heat and inflammation of the parts, and also that of applying cold water, or other cold applications, to the affected limb, are alike prejudicial and dangerous, and are equally to be reprobated. 10th, At the termination of the febrile or inflammatory stage of Gout, as of other inflammatory diseases, the same means of restoring the tone of the system are indicated; viz. chalybeates, bitters, the moderate use of animal food, wine, porter, exercise, and, in the summer, sea-bathing. The eau medicinale of Husson has not maintained so high a character as a remedy for Gout in this country as in Europe. (See American Med. and Philos. Register. Thomas's Practice, 5th Amer. edition.)

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tions, which have little connexion either in their seat, their symptoms, or their termination. We conceive that it ought to be restricted primarily to an affection of the absorbent glands, producing, in the first instance, enlargement, with some degree of inflammation, afterwards a hardened or compacted state of them, in which they are no longer able to exercise their appropriate functions; and, lastly, an ulceration, attended with a peculiar train of symptoms, which sufficiently distinguish it from all other inflammatory affections. Scrofula is a disease which especially attacks certain constitutions or habits of body; the subjects of it are generally persons of fair skins and smooth complexions, and frequently possess great delicacy of feeling and brilliancy of mental powers, indicating what has been termed the sanguine temperament. Its first invasion is during childhood; it is most severe about the period of puberty; and after the adult age, if the frame can bear up so long against its ravages, it gradually declines. It usually makes its first appearance in the glands of the neck, where it forms large ragged ulcers, that are very difficult to heal, but which are often productive of no inconvenience, except the unsightly scars which they leave behind them. It has indeed been supposed, that the discharge from these ulcers is favourable to the general health, by giving vent, as it were, to some humour, which otherwise might produce more dangerous consequences, by affecting some vital organ; but this opinion we are disposed to regard as derived from a false theory, and as not sanctioned by experience. Other glandular parts are, however, often affected, which are more concerned in the exercise of the vital functions, of which those of the mesentery, or other parts more immediately connected with the vital organs, are the most important. When these become the subjects of Scrofula, they prove destructive to health, by preventing the due supply of chyle, and induce a species of atrophy or tabes, which is characterized by a hard and tumid abdomen, and by the extreme emaciation of the face and extremities. It is under this form that Scrofula proves fatal.

It is now generally agreed that it is not a contagious disease; that it is endemic in those countries which have a damp and cold atmosphere; that its exciting cause is improper food, impure air, want of exercise, and a deficiency of clothing; and that these causes act the most powerfully upon the individuals who are predisposed by an hereditary taint, or by previous weakness, but from the influence of which probably no one is entirely exempt. We have stated Scrofula to consist essentially in a disease of the absorbent glands, and we believe that, in every instance, its commencement may be traced to an affection of these organs, but it frequently happens that in the progress of the complaint, glands of other descriptions become diseased, and even parts which are not glandular; two of the most frequent of these varieties are certain affections of the eyes and of the bones. How far these should be strictly called Scrofula, or whether they might not, with more propriety, be considered as distinct diseases brought into action by Scrofula, is a question we shall not now discuss. The same remark applies to the lungs, the glands of which likewise frequently become affected in Scrofula, and give rise to the fatal disease of Phthisis pulmonalis; but this affection is one of so much importance, and is characterized by so many peculiar symptoms, that whatever may be our opinion respecting its nosological character, we must make it the subject of a distinct section.

Many hypotheses have been formed respecting the proximate causes of Scrofula, but we are disposed to think, that they have thrown no real light either upon its nature or its treatment; indeed, with respect to the latter circumstance, we conceive that the doctrines of the humoral pathology, which taught that Scrofula depended upon a morbific matter existing in the blood, which was to be corrected or removed by rigid abstinence, or by a long continued course of purgative medicines, was often productive of serious injury. Indeed the management of Scrofula, although so frequently an object of the greatest interest to practitioners, is a point concerning which the art of medicine has yet made but little advance, and respecting which we are still left in a state of great ignorance and uncertainty. It is inde[illegible] sufficiently ascertained that our great object must b[illegible] improve the general health, and every one will se[illegible] propriety of carefully removing the exciting [illegible], where it can be ascertained, but beyond this [illegible] we have little upon which we can build wi[illegible] degree of confidence. Whether it be the [illegible] the effect of the scrofulous disposition, a deranged state of the alimentary canal is a usual attendant upon the disease, so that purgatives will be frequently found a necessary part of our treatment; and in that variety, where the mesentery is peculiarly affected, the torpor of the bowels often makes it necessary for us to employ the most powerful drastics. The weakness of all the vital powers, which characterizes the scrofulous constitution, suggests the employment of tonics; and they have accordingly, under some form or other, generally made a part of every plan that has been proposed for the cure of the disease; but the peculiar disposition to inflammation which belongs to the sanguine temperament, and the liability which local inflammation has, in those predisposed to it, to assume the scrofulous aspect, always renders their employment critical. This remark applies particularly to cinchona and iron, which, under various forms, have been long prescribed as the grand remedies for this complaint, but which, although they may be beneficial in certain states, where the system is exhausted by long continued disease, probably possess no specific power in counteracting the scrofulous action, and seem but little adapted for the constitutions which are the most disposed to its attacks. In a chronic affection, and in one of so general an operation, we are naturally led to regard the effect of diet as an important agent in the re-establishment of the health; yet on this point very opposite plans have been adopted in the disease now under consideration, for, while a strict antiphlogistic system has been strongly enforced by some practitioners, others have equally insisted upon the importance of a nutritive and even a stimulating regimen. Both these extremes we believe to be injurious, and on this point, as well as respecting the articles of the materia medica, we have perhaps no more explicit rules to guide us than that every thing should be directed towards the establishment of the general health; if the patient be languid and emaciated, we are to supply him with as much nourishment as the digestive organs will admit; but if, on the contrary, he be of an inflammatory habit, we must proceed, although with caution, on the opposite system. The use of sea air, of sea bathing, and of the cold bath generally, respecting which so much had been said in Scrofula, may all be referred to the same principle. To the inhabitants of large towns, who generally pass their time in close apartments, and are immersed in smoke and impure air, the freshness of the sea breezes must be highly salutary; but we apprehend that there can be nothing of a specific nature in the air of the sea, and that many inland situations are even preferable, as being less liable to dampness and moisture. For bathing, however, salt is perhaps always preferable to fresh water, and it has been supposed that sea-water has a beneficial effect upon scrofulous ulcers as a local application, although the evidence for this opinion be not very decisive. In speaking of the remedies for Scrofula, we must not pass by in silence the alleged virtues of mercury, and especially of calomel, which has been held up as a kind of specific in that variety of the disease, where we suspect there to be a scirrhous state of the mesenteric glands. How far mercury, in any form, possesses the power of resolving glandular tumours, we are scarcely prepared to decide, but we are much disposed to refer a great share of the benefit which has been gained by the use of this medicine merely to its power in promoting the operation of the purgatives with which it is usually combined. With respect to all the specifics that have been proposed for Scrofula, the acids, alkalies, earthy and metallic salts, and various vegetable extracts, we confess that we are extremely sceptical as to any benefit that has ever been derived from them. The management of the local affections, whether scirrhous glands, ulcerations, enlargement of the bones, or in whatever form the disease makes its appearance, falls under the especial province of surgery; we shall only remark concerning it, that their treatment appears as difficult and uncertain as is the constitutional form of the disease; and that notwithstanding the numerous plans that have been brought before the public with so much confidence, the cure of these complaints must still be considered as one of the great desiderata of the art.

SECT. V. *Phthisis pulmonalis. Pulmonary Consumption.*

We have already referred to this complaint in the preceding Section, and have noticed its probable connexion with Scrofula; but, whatever be our opinion on this point as a pathological question, it is a disease which amply deserves to be made the subject of distinct consideration. It is characterized by pain in the side or the chest, attended with cough, dyspnœa, and with expectoration, which, as the disease advances, becomes purulent. A febrile state is induced, which ultimately terminates in acute hectic, while in the latter stages there is colliquative diarrhœa and profuse perspiration, attended with excessive debility and emaciation. Although persons of the sanguine temperament are the most subject to this affection, yet it shows so powerful an hereditary tendency, that the children of phthisical parents, whatever constitution or temperament they may possess, and whatever may be their apparent vigour, are always liable to its attacks. Its exciting cause is in most cases to be traced to some circumstance which produces inflammation in the lungs, although, where there is a decided hereditary disposition, it is often very difficult to assign any immediate cause for its invasion. A great proportion of all the cases appear to originate from Catarrh, so that, in our moist and variable climate, where the excess of civilization and refinement has tended to diminish the vigour of the natural constitution of the inhabitants, and where many of the modes of life are peculiarly adapted to render the body liable to suffer from the state of the atmosphere, Phthisis may be regarded as the great scourge of the island. It has been calculated that not less than 55,000 persons are annually destroyed by it, which, if we estimate the total population of England at 12,000,000, will not be very far short of $\frac{1}{2000}$ part of the whole population. When the disease exists in its fully formed state, its character is too well marked to admit of much doubt or uncertainty; but as it often comes on in a very gradual manner, and supervenes upon the affections of the chest, it is sometimes difficult to decide upon its presence. The circumstance which has been usually had recourse to, as forming the diagnosis, is the state of the expectoration, whether it be mucous or purulent; but as this is a point which cannot itself be, in all cases, very easily decided, various tests have been employed for this purpose. Upon the whole, however, we conceive that an attention to the general condition of the patient, to his previous constitution and hereditary disposition, are more important than any one symptom, and will generally enable us to form a correct judgment. Although the state of the lungs in Phthisis has been carefully examined, and the appearances which they exhibit very minutely detailed, there still remains much uncertainty respecting the nature of the proximate cause, or of the manner in which the exciting causes produce the change of structure which the parts experience. When we examine the lungs after death, we find them to be filled with hard tumours, called tubercles, which seem to be composed of indurated glands; these are at first of an indolent nature, but they acquire the inflammatory state, and proceed to suppuration, when the hectic fever comes on, and the disease assumes its characteristic features. We have already spoken of the connexion which there appears to be between Scrofula and Phthisis, and the morbid appearances in the lungs may seem to confirm the idea of the connexion; it must, however, be acknowledged, that the two affections do not bear any exact ratio to each other in the same individual, and even that some whole families are more disposed to Scrofula, and others to Phthisis.

With respect to the treatment of Phthisis, we have little to offer, except a melancholy narrative of the failure of all the plans that have been presented to the public. Indeed, to those who have witnessed the condition to which the lungs are reduced, after they have experienced the ravages of this complaint, it can excite no surprise that all attempts at cure should be entirely unavailing, and must impress the mind with the full conviction that it can only be in the very earliest stages that any relief is to be obtained from the interposition of medicine. It is therefore to the *prevention* of Phthisis rather than to its *cure* that we are to direct our efforts, and this, if it can be accomplished, must depend upon avoiding the exciting causes, especially cold and moisture, and still more, by using every means for fortifying the body against their influence. Warm clothing and airy rooms, moderate exercise, regularity in diet and in all the habits of life, may do much in preventing the extreme susceptibility to catarrh, but for those whose situation will admit of it, and who are disposed to make so great a sacrifice, the removal to a warmer and more settled climate, is the only effectual preventative. How far this is to be advised when the disease has actually established itself, or what stage of Phthisis admits of a chance of cure by this means, is a question on which it is extremely difficult to decide; and there is no point concerning which a practitioner feels a more painful duty imposed upon him, than to pronounce the doom of his patient to be irrevocable, by discouraging his removal, or to subject him to a more painful fate, by separating him from the comforts of his home and the attentions of his friends, without a prospect of relief. In the earlier stages of Phthisis, or where the disease is impending, without the lungs being actually disorganized, our great object is to prevent or counteract inflammation, and yet this must be done in such a way as to diminish the strength in as small a degree as possible. General blood-letting is sometimes admissible, but it must be always had recourse to with caution; we may with less hazard employ topical bleeding, if the pain of the chest and state of the pulse seem to indicate it, and still more blisters, which are perhaps the most powerful remedies that we possess in this disease. We must endeavour to allay the cough by mucilaginous mixtures, to which small quantities of opium may be added, and we may endeavour to allay the fever by diaphoretics; but we must proceed with great caution in the administration of any substance that is intended to act upon the capillaries of the skin, in consequence of the tendency to profuse perspiration, which always exists in the latter stages of Phthisis; the same remark applies also to the bowels. How far any benefit is to be expected from sedatives is still a controverted question; for although we apprehend there can be no doubt of the advantage which is occasionally derived from digitalis, in certain inflammatory states of the chest, yet we are not disposed to expect much from it where the structure of the lungs is affected. As, however, we have no means of ascertaining when this crisis has actually occurred, a cautious employment of digitalis may be generally admissible; but it should always be given in small doses, and we think it may be assumed as a general principle, that if no benefit be obtained from small doses of this medicine, we are not to hope for any advantage by increasing the quantity; on the contrary, we should expect that its deleterious operation would be induced, with all its train of distressing consequences. When the hectic is fully established, nothing is to be attempted but the palliative treatment, and for this we must refer to the remarks that we have already offered on the subject. It only now remains for us to sooth the termination of life, by diminishing, as far as lies in our power, the various sources of uneasiness that from time to time rise up to distress the patient. Every candid practitioner will confess, that beyond this, he can have no expectation of obtaining the least relief from the aid of medicine; and it is a duty which he owes to himself no less than to his patient, to refuse his consent to any of those experiments, which, with whatever pretensions they may be supported, must be regarded as the offspring either of delusion or of empiricism.*

Sect. VI. *Rachitis. Rickets.*

Another disease, which, like Phthisis, is supposed to be nearly allied to Scrofula, if not to be a mere modification of it, is Rickets. It would seem to have first made its appearance in modern times, for it is too remarkable in its symptoms to have been overlooked; and there is probably some reason to believe that it is not now so frequent as it was half a century ago. It is essentially a disease of the bones, in which they increase in bulk, and at the same time lose their firmness, so as not to bear the weight of the parts attached to them without being bent out of their natural form. It makes its first appearance at an early age, and continues until about the period of puberty. During this interval the patient suffers from the immediate effects of the distortion that is produced in various parts of the body, as well as from irregularity in the different organic functions, and especially in those of the digestive organs, so as to induce a great degree of emaciation and debility, which not unfrequently affect the mental

* The causes of Pulmonary Consumption are not exactly the same in this country and Great Britain. With the increase of manufacturing establishments in England we find an increase of the evils which induce pulmonary disorders, and of these evils scrofula may properly be considered among the principal. In the United States scrofula is comparatively little known; but, while we admit the influence of particular employments and modes of living, in inducing consumption, this disease, in most instances in this country, may be ascribed to the sudden vicissitudes we experience in this climate, especially on the sea-board; to imprudence in dress, and improprieties in the use of ardent drink, and other species of dissipation. A common catarrh, especially if frequently renewed, may be placed at the head of the causes of the disorder in this country: it is one of those causes, too, which, while it attracts the least attention, commonly does the greatest mischief. Pulmonary consumption has little association with hæmoptysis. Indeed, this form of disease is far more frequently preceded by catarrhal and pneumonic inflammation than by hæmorrhage from the lungs; and even in those cases where hæmoptysis precedes pulmonary consumption, inflammation of the lungs is usually antecedent to both, and demands the early attention of physicians.

The inflammatory character of pulmonary consumption cannot be too constantly kept in view, and the treatment indicated for the removal of other inflammatory affections of the chest will be found to be most successful in this more insidious disease. In the Quarterly Reports on the disease of the city of New-York the writer has already noticed the point of practice. "We have in many instances employed blood-letting with the most happy effects, in many cases of incipient *Phthisis*, even where strong hereditary predisposition existed. Indeed we are induced, from some late observations on the subject, to express the opinion, that in the commencement of Phthisis, as in peripneumony, blood-letting is not sufficiently employed, but is too frequently neglected until the inflammation has so far extended that suppuration becomes inevitable. Nor do physicians in general appear to have been sufficiently attentive in describing the symptoms characteristic of the first or inflammatory stage, and consequently have been regardless of that active antiphlogistic treatment which alone can prevent the tuberculous or suppurative stage. In as much as suppuration, or a purulent secretion from the lungs, necessarily implies preceding inflammation, we conceive too early attention cannot be given to the premonitory symptoms which announce the inflammatory stage, but which are frequently so inconsiderable, being seated in the less sensible, the cellular portion of the lungs, that both physician and patient are alike regardless of the present symptoms, and of the consequences to which they lead. Instead, therefore, of trusting to syrups, anodynes, pectorals, ptisans, or the Iceland moss, to allay the hacking cough and pains in the chest, which indicate the first approach of the disease, we earnestly recommend the same active treatment, by blood-letting, blisters, and other means of diminishing excitement, as are employed in the treatment of a pleurisy, or any other acute inflammation; and we could add, in confirmation of this view of the subject, many recent cases, in which the practice here recommended has been attended with the most beneficial results." *Amer. Medical and Philosophical Register.* See also *Rush.* Thoughts on *Pulmonary Consumption.*

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as well as the corporeal faculties, and ultimately proceed to a fatal termination. When the disease assumes a less acute form, the powers of the constitution finally overcome the violence of the disease; but the deformity of the bones still continues; and when it has affected the trunk of the body, it often materially deranges some of the functions, and leaves the parts in a state from which they can never afterwards recover themselves. The cause of Rickets is not yet ascertained; many of the circumstances which tend to induce Scrofula seem also to favour the appearance of Rickets; but we are disposed to regard them as distinct complaints, because we do not perceive that the symptoms are necessarily connected together; but, on the contrary, that they commonly attack certain individuals separately, and are not convertible into each other. The affection is generally thought to be hereditary, yet the tendency is not so obvious in this case as in Scrofula, or in Phthisis; and we perpetually observe examples, where a single member of a family is diseased without any other suffering from it. The proximate cause of Rickets appears to be a change in the physical and chemical constitution of the bones, the animal matter which enters into their composition being probably in a morbid state, and the earthy matter either deficient in quantity, or altogether wanting; but in what way these changes are effected, or how they follow from the exciting cause, we are altogether unable to explain.

We have very little to offer respecting the cure of Rickets, more than that we must adopt every means which lies in our power for removing the supposed exciting causes, and for promoting the general health. The disease seldom exhibits any inflammatory symptoms, so as to render bleeding necessary; but the derangement of the digestive organs, and the torpor of the alimentary canal, make purgatives an essential part of the treatment. To these tonics and stimulants may be occasionally added; but we do not conceive that any great benefit is to be derived from them, unless where the appetite is particularly defective, and when the bowels are brought into a natural state. Still less confidence do we place in any of those remedies, which have been from time to time offered to our notice, as possessing a specific effect in Rickets, such as phosphate of lime, upon the principle of supplying the deficiency of this substance in the bones, or the carbonate of ammonia, for neutralizing the supposed acid in the blood,—remedies which we believe will be found as useless in practice as we apprehend them to be incorrect in theory. It is a difficult point to determine upon the means that ought to be adopted for counteracting the mechanical deformity that arises from the state of the bones. Perfect rest in the horizontal posture has been recommended; but in very young children this is almost impossible to be strictly adhered to, while the want of exercise is itself a means of increasing the tendency to disease; nor indeed does it appear, that, with all our care, we are able to prevent the bones from being distorted by the action of the muscles that are attached to them, or by the weight of the different parts pressing upon each other. Upon the whole it may be desirable to recommend the horizontal in preference to the erect posture during a part of the day; but we should not sacrifice to this system, the benefit that may be supposed to arise from the general salutary influence of air and exercise. It appears to be agreed, that the mechanical contrivances for supporting or straightening the limbs are not of much use in Rickets.

Sect. VII. *Syphilis.*

The treatment of this disease is considered as rather falling under the province of the surgeon than of the physician, yet it offers so many curious subjects for speculation, and involves so many interesting questions of pathology, that we cannot pass it by in our system, although exclusively appropriated to the practice of medicine. Notwithstanding Syphilis is a disease of the most frequent occurrence, and one that has engaged the attention of medical men for some centuries, there are many very important points respecting it which still remain undecided. The first accounts that we have of the unequivocal symptoms of Syphilis appeared about the end of the 15th century; but how it was produced, or from what quarter of the world it proceeded, are not yet correctly ascertained. The disease, in its ordinary form, is communicated by the actual contact of parts previously infected, which necessarily happens most frequently to the generative organs, and, independently of their situation, it is probable that their structure, as possessing a surface covered by a thin cuticle, and furnished with secreting glands, is peculiarly liable to receive the infection. The first symptom is a local ulcer, to which the name of chancre has been applied, and which seems to be altogether a local affection; but it is a property of the chancre to generate contagious matter, which is capable of being absorbed, and of contaminating the system at large. Besides the local syphilitic ulcer or chancre, there is another form of venereal infection, in which, without any wound or breach of the cuticle, a mucous, or secreting surface, becomes inflamed, and exudes a large quantity of semi purulent matter, which has the property of inducing the same state on a similar mucous surface with which it is in contact; to this the name of Gonorrhœa has been applied. It has been a much disputed question, in what manner these two affections are related to each other, whether they are distinct diseases, or whether they originate from the same poison having experienced some modifications, or assume a different aspect from the different nature of the parts to which it is applied. Upon the whole, perhaps the most decisive facts are in favour of the diversity of the two diseases; but, at the same time, we must remark, that some authors of the first eminence profess the contrary opinion. It would be inconsistent with the brief and general view which we profess to take of the subject, to detail all the symptoms of this proteiform disease, which, as it affects a great variety of parts and structures, and attacks indiscriminately all constitutions and temperaments, exhibits a greater diversity of appearances than perhaps any other complaint to which the human frame is obnoxious. If the local ulcer be not cured by the appropriate remedies, and if means be not taken to prevent the contamination of the system, a portion of the infectious matter is taken up by the lymphatics, and seems to be carried into the mass of the circulating fluids. In its passage along these vessels it usually affects some of the glands, producing in them tumours, which are styled buboes, and afterwards abscesses, which partake of the same infectious nature with the original chancre, and still farther contribute to the general diffusion of the disease. When the system becomes in this manner completely contaminated, there are certain parts of the body which are peculiarly disposed to manifest the presence of the poison, and in these it exhibits itself in a uniform order of succession. It first appears in the mucous membrane of the throat and fauces, producing an inflammation and superficial ulceration, which terminates in an erosion and loss of substance, so as materially to injure the form and organization of the part. About the same time, various portions of the skin begin to exhibit the effects of the disease; brown or copper-coloured spots make their appearance, from which a quantity of matter exudes, which concretes into a scurf. This, when it falls off, is succeeded by another scurf, and so on until at length ulceration is established. The next set of symptoms, or the next order of parts that is infected, is the periosteum, and the various appendages of the bones; these become thickened, and at length give rise to painful tumours, called nodes, until the structure of the bones themselves is finally disorganized. There are ceatain bones which seem peculiarly disposed to suffer by the syphilitic poison, especially the small bones of the palate and the nose; and when the disease has got firm hold of the constitution, they are entirely corroded, so as to cause a great defect in the speech, and the most dreadful deformity of the countenance. Along with these symptoms, which are all more or less of a local nature, although depending upon the general diffusion of the poison, the powers of the constitution begin to suffer, the appetite fails, emaciation and loss of strength ensue, hectic supervenes, and the disease terminates fatally. These symptoms are usually recognized as the effects of chancre, and it has been a much disputed point, whether a similar train of complaints can be induced by the poison of gonorrhœa. This we are disposed to decide in the negative; but we do so, as in the former case, in opposition to the judgment of many persons, who are the best able to decide upon the subject. Whatever opinion, however, we may form respecting the contamination of the system by the matter of gonorrhœa, the inflammation with which it is attended has the power of extending itself along the urethra, and the ducts connected with it, thus producing tumours of the neighbouring glands, and especially of the testes. The tumours thus formed, unless the inflammatory action be subdued by proper applications, may proceed to suppuration; but the matter thus generated does not appear to be capable of contaminating the system at large; at least this is the opinion of those who regard the poison of gonorrhœa to be different from that of chancre, or the proper Lues venerea.

This very general outline of the leading features of Syphilis will be sufficient to prove, that many difficulties attach to the pathology of the disease, and we shall find that there is not less obscurity with respect to its treatment. And this does not arise from the same circumstances which we meet with in the management of other diseases, depending upon the obstacles that present themselves to our researches into the operation of medicines on the living body; but here we have to encounter the most direct contradiction of evidence, and we are called upon to decide between the opposing opinions of those who might be supposed to possess the most unexceptionable means of ascertaining the truth. A controversy has subsisted for some time on the question, whether the same general remedies were necessary in gonorrhœa as in chancre, a question which is obviously connected with the controversy respecting the identity of the infection generating the two varieties of the disease. With respect, however, to the proper syphilitic poison, and to its constitutional symptoms, under whatever form they manifested themselves, there was, until very lately, but one opinion, that the only remedy is mercury, the sole question for consideration being, in what way this medicine should be exhibited so as to produce the least injury to the constitution. Every one agreed that mercury possessed a specific power over the venereal poison,—that no other medicine possessed the same power; and so firmly was this opinion established, that it was esteemed a sufficient diagnostic of the presence of the disease, where the symptoms assumed a doubtful aspect, that they yielded to the action of this remedy. But, notwithstanding the supposed invaluable property of mercury as an anti-syphilitic, practitioners were aware that it is a substance which possesses an unfavourable effect upon the system, if used in too large a quantity, and it was admitted that in certain cases, it was a question of extremely difficult solution, whether certain morbid appearances were to be ascribed to the disease itself or to the remedy. Still, however, no one thought of calling in question the indispensable necessity of mercury for the cure of Syphilis; and the injurious effects which it seemed occasionally to produce, were attributed either to some idiosyncrasy in the constitution of the individual, to the injurious administration of the remedy, or to the improper management of the patient while under its influence. A few years ago some practitioners of eminence began to take a different view of the subject; they conceived that there were certain affections, which had always been classed as syphilitic, in consequence of the mode in which they were communicated, and the general aspect of their symptoms, but which were capable of being cured without mercury; from this circumstance they concluded that they must necessarily be of a different nature, and they accordingly termed them pseudo-syphilitic. It then became a point of great importance to form a diagnosis between these cases and those of genuine Syphilis; for not only was the Pseudo-syphilis curable without mercury, but it seemed to be even aggravated by the use of this substance. As the investigation continued to be pursued, opinions arose that were still more remote from those that had been formerly adopted; it was now advanced, that mercury is not essential to the removal of Syphilis itself, and farther, that a considerable part, if not the whole of the constitutional symptoms, are really the effect, not of the disease, but of the deleterious operation of mercury.—We state these points, not as articles of our own faith, for we confess our scepticism upon the subject, but as what have received the sanction of great authorities, and this not of mere theorists, but individuals who have been actively engaged in the details of practice, whose testimony, had it not counteracted all our former experience, and opposed some of the opinions which seemed to stand upon the most incontrovertible evidence, we should have been the most disposed to receive without hesitation It seems that we must regard the public sentiment on this question as now in the progress of a great revolution, the result of which it is impossible to predict; after various oscillations of opinion, we shall perhaps finally settle in a medium state: we shall probably find that there are either different kinds of venereal infection, or that it undergoes certain modifications, which cause it to be differently acted upon by the same remedy, or to require different remedies for its removal.—The general and indiscriminate use of mercury we may safely pronounce to be improper; and when we consider the quantities in which it has been given, with so little regard to peculiarity of constiution, or differences of temperament, we can scarcely doubt that its effects have been almost as injurious as those which would have resulted from the ravages of the disease which it was intended to cure. Yet we should be acting in opposition to the concurring testimony of the whole medical profession for some ages, were we not to allow of the specific effect of mercury over that form of Syphilis which usually presents itself to our notice, so that we may venture to assert, that if we are to give up this point, there is no one position in the practice of medicine which must not be regarded as disputable. For reasons which have been already stated, we shall not enter upon the consideration of the various local forms of the disease; and while such a schism exists respecting the effect of mercury, it would be premature to enter upon any pathological speculations respecting the mode of its operaration. We shall only observe, that, independent of its anti-syphilitic power, its action on the various organs seems to be that of a stimulant, increasing their natural powers, whether of absorption, secretion, or excretion, as well as the vital functions of contractility and sensibility. We know not how this stimulating property can have any influence over the neutralization or expulsion of the syphilitic virus; we see no connexion between the two effects, nor can we conceive of the nature of the relation which they bear to each other.*

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* On a subject of such importance as that of Venereal complaints, the American editor is induced to offer the following extracts from an Essay on Mercury, by Dr. Francis, the present Professor of Obstetrics in the University of the state of New York. For further observations, the reader is referred to the American Medical and Philosophical Register, vols. iii. and iv. AMER. ED.

"Among the principal advantages which the corrosive sublimate possesses over that of every other preparation of mercury are, that, judiciously administered, it is particularly mild and safe in its operation, will admit of a more extensive use in all the various forms of lues venerea, and subject the patient to fewer inconveniencies: that it readily enters into the general circulation, becomes miscible with the several fluids of the body, the soonest arrests the progress of the complaint, and eliminates the morbid matter through those emunctories best calculated for that purpose: that it supersedes the necessity of salivation, by its action on all the secretions, and by promoting especially the cuticular discharges, and the evacuations from the kidneys: that it is the only preparation to be depended on in those peculiar habits of body, so susceptible to become salivated by every other form of mercury now in use: that, in its ultimate effects upon the constitution, it is attended with comparatively no injury. These facts are indeed truly important, and many of them are granted by those who altogether reject the use of this preparation.

"It is not a little unfortunate for the advocates of other combinations of mercury, that the objections which have been brought against the corrosive sublimate are so dissimilar. It has been assigned as a reason against the preparation itself, that it has failed of its salutary effects by being given in too small doses. By some its anti-venereal properties are said to be lost on account of its too readily exciting the cuticular discharge; by others it is owing to its defective action on the secretions of the skin and mouth. By some it is admitted to be beneficial in the primary stage of the disease, and by others it is contended that it is calculated to remove only secondary symptoms. It is also declared that it is violent and uncertain in its operation, and that it does not render the cure permanent. Some of these objections are, indeed, weighty, and, were they well founded, would fully justify the abandonment of this peculiar combination of mercury; but if the least reliance is to be placed upon the experience and observation of those who have employed the corrosive sublimate with the most disinterested and honourable views, and solely to determine upon its anti-venereal powers, evidence sufficient to prove the fallacy of these objections, and derived from indubitable sources, might be adduced. The testimony of Dr. Locher, of the Vienna hospital, is so full and explicit, that it were an omission not to insert it. Having witnessed the "horrid calamities," arising from salivation and other abuses, which existed in that institution, in the management of venereal patients, upon the recommendation of Van Swieten, he made trial of the corrosive sublimate. From the year 1754 to 1762, he cured by it no less than four thousand eight hundred and eighty persons, *without inducing salivation;* and testifies, that 'no persons died, or experienced the least painful and dangerous symptoms, in consequence of this remedy.' In the cases in which the same preparation was recommended by Pringle, the cures that were effected were permanent, and, from the repeated experience of many other distinguished practitioners, the same result ensued. Multa nobis exempla visa sint luis venereæ, murcurio sublimato corrosivo perfectè sanatæ.

"To enter into a consideration of the treatment of the various symptoms which characterize lues venerea, in its simple and in its more confirmed state, is not deemed necessary, nor will it here be attempted. Fully convinced, as the writer is, of the decided advantages which the corrosive sublimate, as an anti-venereal remedy, possesses, in most cases, over other mercurial preparations, he cannot forbear adding a few further observations, for the purpose of recommending to more general use this combination of mercury.

"A very forcible reason why a preference ought to be given to the corrosive sublimate as an anti-venereal remedy, is the mildness of its operation, when compared with most other mercurial preparations. In the mind of the judicious practitioner, there need exist no apprehensions of the severity of its action; few articles of the materia medica can be more readily accommodated to the peculiar condition of the patient, and the nature and stage of the disease. The evidence of its mildness may be adduced from the salutary effects which it produces in the constitution of delicate children, and even of infants. In not a single instance, within the recollection of Dr. Hosack, has it ever been followed by pernicious consequences, though long employed by him, in many cases in which the patient laboured under some hereditary taint, obstinate cutaneous eruption, or other symptoms indicating an alterative course of remedies. The destructive effects which have been mentioned as attending its administration, such as excessive pain and irritation of the stomach and bowels, headach, fever, &c. may, in certain cases, arise from some peculiarity of constitution obnoxious to mercurial remedies, but are doubtless, in general, to be attributed either to the improper preparation of the corrosive sublimate, or to its having been given in undue quantity. It has been asserted that this mercurial salt is particularly injurious to those labouring under pulmonary affections. That this objection is ideal, or rather that, of all mercurial preparations, it applies with least force against the corrosive sublimate, must be evident, upon considering the general operation of this form of mercury. Every combination of this mineral may prove more or less injurious in the forming stage of consumption, on account of the active inflammation which is then present, and the additional irritation attendant upon mercurial action. For it may be laid down as a general principle, that mercury is in itself injurious, when administered to any considerable extent, during the existence of inflammation and febrile excitement, and before the employment of blood-letting, or other evacuants.

"From the mild operation of the corrosive sublimate, properly prepared, may be inferred the utility of its employment in persons of delicate habit, and in those cases especially where the constitution is materially impaired. In cases of this kind its exhibition is followed with the best effects. That the tonic powers of the system may, however, in certain instances, be so far weakened as to render the employment of every form of mercury not only inefficacious in the removal of syphilitic complaints, but productive of the most distressing symptoms, and, consequently, that the use of the oxygenated muriate will at times be the cause of much inconvenience and real suffering, there is left no room to doubt. In irregular cases of this nature, the remedy necessarily fails of producing its ordinary beneficial effects; and as it becomes an additional source of irritation, it greatly increases the debility which already prevails. These effects, as has just been remarked, do not result from the exclusive employment of any particular form of mercury; they seem

Sect. VIII. *Scorbutus. Sea Scurvy.*

This disease is characterized by general muscular debility, by livid spots on various parts of the body, sponginess of the gums, and hæmorrhage from the alimentary canal. It is one of those diseases in which the soft parts of the body seem to have experienced a morbid change in their physical and chemical composi-

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to arise less frequently from the corrosive sublimate, but are common to all mercurial preparations. For, if the constitution has not the power to support the action of mercury, vain is the attempt to eliminate from the system the virus of lues venerea. Hence, in the treatment of certain diseases of hot climates, especially in unhealthy situations, it is not an uncommon practice to administer the bark daily, during the whole course, for the purpose of enabling the constitution to bear a sufficient quantity of mercury to subdue the complaint. Upon the same principle, that learned physician and distinguished writer, Dr. Chisholm, maintains, that in the management of disease a reduction of plethora at the commencement, and the augmentation of the vis vitæ in the advancement, are to be particularly attended to, in order to ensure the successful administration of mercury. Dr. Ferriar has observed instances in which the venereal disease itself assumed a peculiar character, owing to debility, where the debility so far prevailed that the constitution had not power to form a genuine syphilis. When this happens, mercury will not effect a cure. 'Under these circumstances,' adds Dr. Ferriar, 'I have advised with success a course of tonics, without mercury, to raise up the constitution to a higher level. Mercury may then be expected to cure.' "

Again, " That the corrosive sublimate, of all mercurial preparations, soonest affects the system, and arrests the action of the venereal virus, is a truth grounded upon the concurring experience of the most distinguished practitioners.

" It is but proper to state, that the preparation of mercury now recommended, has been employed for the last twenty years in the private practice of Doctor Hosack, and during his attendance at the New-York State Prison, New-York Hospital, and the Alms-house of this city, as physician of those institutions. It has invariably been found to be the remedy best calculated for the removal of lues venerea, both in its primary and secondary stages; and not a single case is recollected in which the cure has not been permanent. Those injurious effects upon the stomach and bowels, which are so much apprehended, were avoided by a cautious employment of the medicine, and by a due consideration of the peculiarities in the constitution and state of the patient. From this form of mercury, salivation scarcely ever was induced; and, while under its influence, the employment of the decoct. guaiac. et sarsaparil. was found to be an excellent auxiliary in recent cases; and in the secondary stage of the disease, where the patient had been neglected, or when improprieties in the cure had been committed, it was almost indispensable.

" Though satisfied that the oxymuriate of mercury possessed full claims to the title of a powerful anti-venereal remedy, from a perusal of the testimony published in its favour, and from a personal knowledge of the result of several cases in which it had been employed; with the view of more fully determining so important a matter, and to ascertain, as far as practicable, whether the objections which have been stated against it, particularly those of the distinguished Mr. John Pearson, were founded in reality, at the suggestion of the writer, the use of the corrosive muriate of mercury was adopted in the spring of the year 1811, in the New-York Hospital. From the extensive charity which this excellent institution afforded, there was abundant opportunity of seeing almost every form of this disease, from the more mild to the most aggravated; cases of recent infection, and those of long standing. After a careful examination of the histories of a great variety of cases, a selection was made of several of those patients who were affected with the primary, and of others labouring under the secondary stages of this disease. The corrosive sublimate was given, in some instances, in the form of the spirituous solution, and in other instances made into pills; the decoction of guaiacum and sarsaparilla was employed as an auxiliary, and occasionally recourse was had to the application of the lunar caustic; but the external use of every preparation of mercury was omitted. In no one instance were there unpleasant effects produced by the action of this mercurial salt; and, contrary to the opinion entertained by Mr. Pearson, of the efficacy of this remedy, the result of these several cases was attended with complete success.

" To multiply further arguments, or offer additional proofs in favour of the oxygenated muriate of mercury, does not seem necessary. It may be confidently pronounced a safe, convenient, and efficacious remedy in lues venerea. How far a too ready acquiescence in the force of authority may be assigned as the cause of that want of confidence in the virtues of the corrosive sublimate, and of that apprehension of its pernicious qualities which at present prevails among many practitioners, it is impossible to ascertain. It is evident that the opinions of Mr. Pearson are those chiefly which have been adopted and reiterated by every subsequent writer who has opposed the use of this mercurial combination. But the success attendant upon the administration of the oxymuriate of mercury furnishes the most satisfactory answer that can be given to those who have denied its efficacy. Upon the successful result of the cases of lues venerea, which existed in the New-York Hospital in 1811, the corrosive sublimate again became the principal anti-venereal remedy in that extensive establishment. This form of mercury, since that period, has also been in general use in the New-York Alms-house, in the treatment of syphilis in its different stages; and in most instances it is now employed for the same purpose by the physicians of the City Dispensary. The observation and experience of the writer, during the last three years, in a number of unequivocal cases of lues venerea, have tended to corroborate the favourable opinion he formerly expressed, and induce him to recommend, with increased confidence, a more extended application of this preparation of mercury.

" Various are the forms in which the corrosive sublimate has been used in the different stages of lues venerea, and in other disorders indicating an alterative course of remedies. Its external application, in the form of ointment, has been recommended by some; but against this practice many forcible objections might be brought. The internal use of the spirituous solution of Turner, in which the proportion of ardent spirits to the mercurial salt was remarkably small, has justly been accused as the source of much mischief. The formula of Van Swieten deserves a decided preference; for the muriated quicksilver, dissolved in spirits, and exhibited in doses limited to the quantity of one-eighth of a grain, two, or, at most, three times in twenty-four hours, seldom produces the least nausea, or any derangement of the stomach or bowels.

" The corrosive sublimate, dissolved in common brandy, in the proportion of two grains of the salt to one ounce of the liquid, is a valuable and convenient preparation for delicate children. It may be given with the greatest safety, in a little sweetened water, to the amount of three or four drops to a child of one year, and repeated three times a day; and to a child of two or three years old, six or eight drops three times a day. After its employment two or three days, the dose may be increased to ten or twelve drops.

" A solution of the oxymuriate of mercury in common distilled water, with the addition of a little muriated ammonia, (sal ammoniac,) is also a judicious and safe pharmaceutical combination.

" But the best form of administering the corrosive sublimate is that in which this mercurial salt, united by solution with the muriate of ammonia, is made into a mass with the crumb of wheat bread, and then divided into pills.

℞. Oxymuriat. Hydrarg.
Muriat. Ammon. aa gr. xv.
Aq. distillat. vel. font. ℥ ss. Solutioni addatur
Panis medul. sic. q. s.
Ut fiat massa, in pil. cxx. dividenda.

" Every pill in this prescription contains, if the materials be uniformly combined, the eighth of a grain of the corrosive sublimate. The dose can, therefore, easily be regulated with the greatest accuracy. Of these pills one is to be taken every night and morning, though, in some aggravated cases, another pill may be taken at the middle of the day, with additional advantage. In this manner a quarter of a grain of this preparation of mercury will, in ordinary cases, be taken in twenty-four hours; and in the more severe form tion; for not only do we find a depravation of all the functions, but, if we except the bones, there appears to be an alteration in the nature of all its constituents, both solid and fluid. The exciting causes of Scurvy are ascertained to be all those circumstances which deprive the body of its due quantity of nutrition, or weaken the action of the digestive organs, and prevent them from completing the office of chylification, such as exercise and fresh air; and upon the same principle we find, that whatever depresses the spirits has a powerful influence in aggravating scorbutic affections. As its name imports, it generally makes its appearance among sailors during long voyages, when they have been for a long time without a supply of fresh provisions; but precisely the same symptoms have made their appearance among the inhabitants of beseiged towns, or among armies who were exposed to the same deficiency of fresh food; and from a similar cause Scurvy is generally endemic in Greenland, and the other northern countries, where the inhabitants are necesssarily deprived, during the greater part of the year, of all vegetable food. The proximate cause of Scurvy, or the way in which the exciting causes induce the symptoms, has been the subject of much speculation, and has given rise to many pathological hypotheses, all of which, however, we apprehend will prove to be without foundation. The symptoms which arise from the mere privation of food, do not correspond to those which form the leading features of Scurvy, nor do we know in what way the peculiar condition of the soft parts which constitutes this disease can proceed from the use of salted provisions, of impure water, or of a putrid state of the substances received into the stomach. With respect to the theories which ascribe Scurvy to some chemical change in the blood, such as a defect of oxygen, they may be considered as altogether unfounded, and resting entirely upon the most fanciful analogies; and although the old hypothesis, which conceived the fluids to be in a putrid state, is deficient in evidence, still it appears to be less inconsistent with the acknowledged phenomena. We must therefore consider this to be one of those points of medical theory which are not yet ascertained, and not, as far as we can judge, referable to any general principles. Fortunately, however, the want of a correct theory has not prevented us from acquiring an effectual manner of treating the disease, for we may consider Scurvy as one of the few complaints for which we possess a certain specific, which in all cases removes the disease, provided no circumstance intervenes to counteract its effects. This remedy is the citric acid, which effectually cures Scurvy almost in its worst form, provided only that we have it in our power at the same time to remove the exciting causes. We find indeed, that when we are able to afford the patient a proper supply of fresh vegetable food, the symptoms will generally yield without the use of the citric acid, although this will, in all cases, contribute to expedite the cure. It does not appear that any other acid possesses the same power in

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of lues venerea, the additional eighth of a grain. Instances may occur, in which it may be advisable to administer half a grain daily. Mr. Bell has given a grain of the corrosive sublimate, divided into four or five doses, but has not been able to continue this quantity for more than two or three days together.

"The corrosive sublimate to the amount of one quarter of a grain a day, and, in some cases, an additional eighth of a grain, in pills, may be continued for a long time, without producing the least inconvenience in the stomach and bowels, and with greater certainty and more beneficial effect than the same quantity of this salt, in the form of the spirituous solution. The use of the corrosive sublimate ought to be continued two or three weeks after the disappearance of the disease, in order more effectually to accomplish a radical cure.

"It has already been observed, that the oxygenated muriate of mercury operates more readily on the constitution than any other form of this mineral, and that even in very small quantity it soonest arrests the progress of venereal symptoms, and, by its general action, eliminates the poison of the disease. It deserves to be stated, that during the use of this preparation, all those precautionary measures, with regard to diet and regimen, which are generally recommended by writers, need not be regarded with the same scrupulous attention, while in the use of the corrosive sublimate, as during the employment of other mercurial medicines. For as the corrosive sublimate rarely affects, to any considerable degree, the salivary glands, those subjected to its use are not rendered so susceptible to the influence of cold, and the physician is seldom under the necessity of devising means for the purpose of obviating the pernicious consequences of salivation. Instances of peculiarity of constitution may occur, which require much management and discretion in the use of this remedy. Mr. Bell has observed, that opiates have not the same influence in preventing an undue action of the oxymuriate of mercury upon the stomach and intestinal canal, which they commonly have with other mercurial preparations. The limited experience of the writer has not in any case corroborated this opinion: on the contrary, he has found an occasional recourse to small quantities of opium highly serviceable.

"As some one or more articles of the vegetable kingdom are in general employed in those cases, in which the corrosive sublimate is administered, it perhaps would not be irrelevant to examine how far they are entitled to particular confidence. It may be proper to remark, that of the many substances which have been employed as auxiliary remedies, or are now in use, the *lignum guaiaci* and the *radix sarsaparillæ* unquestionably claim the first notice. They are acknowledged to be useful during the administration of the oxymuriate of mercury, in cases of recent affection; and, in the secondary symptoms of the disease, for the removal of the evils which have taken place from the injudicious employment of mercury, &c. their salutary operation has been uniformly evinced.

"The compound decoction of guaiacum and sarsaparilla may readily be prepared in the following manner:

℞. Rasur. ligni guaiac.
Rad. sarsapar. fissæ aa. ℥i.
Coq. in aq. font. ℔iij. ad ℔ij.

"Of this decoction the above quantity, taken warm, ought to be drunk within the twenty-four hours. Of its effects as a powerful alterative for the removal of some of the most painful symptoms of lues venerea and obstinate cutaneous affections, indubitable evidence exists in the pages of the old, and in those of the most eminent modern authors. During a period of more than forty-five years, its virtues for these purposes have been tested in the practice of that learned and distinguished physician, Dr. Samuel Bard, and for more than twenty years in the practice of Dr. David Hosack. Its salutary properties appear to be owing chiefly to the general excitement which it produces, and to its action as a diaphoretic. When had recourse to, while in the use of mercury, particularly in the treatment of those cases where the disease is of long continuance, it proves eminently useful, by promoting the natural tendency which the corrosive sublimate possesses to increase the cuticular discharge.

"The compound decoction of the guaiacum may be taken with success for the removal of many of the morbid effects produced by the improper employment of the different preparations of mercury, and for restoring the constitution to its wonted vigour. The advantages arising from the use of the *Rob Anti-syphilitique,* for which so enormous a consideration is demanded, may with confidence be attributed principally to the sarsaparilla which enters into its composition."

Scurvy with the citric, except so far as they may contribute, in certain states of the digestive organs, to aid in the process of chylification.

We may remark, in connexion with this subject, that no department of the medical profession has conferred more benefit upon mankind than that which respects the health of seamen. To so great a degree of perfection are we arrived in every part of the naval police, with respect to food, clothing, and discipline, both moral and medical, that scurvy is now become a comparatively rare occurrence; the longest voyages are accomplished with little risk of disease, and even with less injury to the health, than what usually happens to the same number of men placed under the ordinary circumstances of civil life.

Sect. IX. *Hydrops. Dropsy.*

The third order of the Paratrepses consists of the Hydropes, a set of diseases which appear to originate from an affection of the minute vessels belonging to the serous membranes that line the close cavities of the body. These vessels, in their natural state, secrete a serous fluid, which is taken up by the absorbents as rapidly as it is discharged; but in certain conditions of the system these two operations do not proceed in exact proportion to each other, in consequence of which an accumulation of fluid ensues, which produces the diseases in question. This accumulation may take place in the cellular texture, which pervades all parts of the body, essentially consisting of a series of small cells, that are furnished each of them with the appropriate apparatus for secretion and absorption.

This species of Dropsy has obtained the name of Anasarca, and, according to circumstances, it either extends through the whole of the cellular texture, or occupies certain portions of it only. The exciting causes of Anasarca, as well as of Dropsy in general, are various, and not well ascertained; it is a frequent sequel of other diseases, by which the vital powers in general, and especially the contractility of the muscular fibre, appear to be weakened; it is also induced by other debilitating causes, as excessive evacuations, want of proper nutrition, over fatigue or exhaustion. There is also another set of exciting causes, which appear to be more of a mechanical nature, and which may be all referable to a physical obstruction of the absorbent vessels; and there is a third set of exciting causes of dropsy, which are not strictly to be included in either of the preceding classes, viz. various circumstances which impede the digestive functions, especially structural diseases of the different abdominal viscera. In some cases indeed these affections may be attributed to the pressure of the parts, when they become indurated, upon the thoracic duct or the trunks of the absorbents, but in other cases it would seem to proceed from a constitutional cause; the Dropsies that are produced in this way are principally those of the cavity of the abdomen, to which the term Ascites has been applied. There appears to be in some individuals, what may be called a Dropsical Diathesis, where serous effusion, in one or more parts of the body, is liable to take place from very slight causes, or perhaps without any assignable cause whatever.

The proximate cause of Dropsy must obviously consist either in increased secretion or in diminished absorption of the serous fluid, unless we suppose that these two states can exist at the same time; we have, however, considerable difficulty in deciding to which of the two causes each individual case should be referred, or to determine in what manner some of the exciting causes can operate. As they are in most cases debilitating, we might conclude that the deficiency of absorption was a more frequent occurrence than the excess of secretion; and the treatment which is found most successful in Dropsy; may probably seem to countenance this idea, yet it must be acknowledged that the pathology of the disease is altogether obscure, and that we have no direct facts to guide us in our decision. One of the most remarkable symptoms in Dropsy is the change which is effected in the state of the urine; it is much diminished in quantity, and is altered in its quality; the proportion of the watery part to the solid contents being considerably reduced, so as to render it thick and high coloured, and to cause it to deposit, as it cools, a copious sediment. In some cases of Dropsy the urine has been found to coagulate by the application of heat, proving that it contains a portion of albumen; and as the presence of albumen has been conceived to indicate a different condition of the system from that which prevails in the more ordinary kinds of Dropsies, considerable importance has been attached to this circumstance, both in a pathological and a practical point of view.

In attempting to cure Dropsy we are first to inquire whether the disease be primary or symptomatic; and if we conclude it to be only symptomatic, we are of course to apply our remedies to the removal of the original disease. But when this cannot be accomplished, or when we are not able to detect any primary affection, we must direct our attention to the Dropsy itself; and the two obvious indications will be, to remove the effused fluid and to prevent its re-accumulation. The effused fluid may be removed by puncturing the cavities which contain it, and thus mechanically discharging it; but this seldom affords more than mere temporary relief, as, while the same constitutional disposition remains, the water again rapidly accumulates, and it sometimes even appears that it is effused in larger quantity than before, and that the general health is injured by the operation. It must also be remarked, that dangerous consequences occasionally ensue from the punctures, which, however carefully made, are disposed to assume the gangrenous state, from the feeble condition of the vital powers. We must therefore attempt to remove the effused fluid through the intervention of internal remedies, and of these the most effectual are such as produce an increased action of some of the excretory organs, especially the intestinal canal and the kidney. In consequence of that intimate connexion which subsists between all parts of the system, we find that if by any means we produce an increased discharge from one organ, all the rest seem to be excited in the same manner. What is the exact nature of this connexion we are scarcely able to ascertain, but we are acquainted with the effect, and we have frequent opportunities of employing it with advantage in the cure of disease. We have stated that purgatives and diuretics are the two classes of medicines which are usually had recourse to for removing collections of serous fluids, when effused into any of the cavities of the body; and it is accordingly to these substances, and especially to the latter, that we generally look for the cure of Dropsies of all descriptions. When we are able to produce the desired effect upon the kidney, we indeed seldom fail in accomplishing our purpose, but it unfortunately happens that there is no class of medicines that is so uncertain and apparently so capricious in their operation as diuretics. The number of articles that have been employed for this purpose is very considerable, and they are so very different in their nature and sensible properties, that we can scarcely conceive them to act upon the same principle, or even to produce the same effect upon the body. Many of them indeed, it may be concluded, are entirely inert, and have acquired their reputation, solely from some accidental circumstance; but there are others of obvious activity, although even of these it is not easy to say in what manner they act, or how substances of such different qualities can all conduce to the same end. The medicines that are esteemed the most efficacious diuretics are squills, digitalis, cream of tartar, and certain preparations of mercury. Of these the squill is the one which is the most certain in its effects, and which seems to be applicable to the greatest variety of cases, so that unless there be some peculiarity in the constitution, which prevents us from administering the medicine in proper quantity, or some structural disease which counteracts its operation, it seldom fails in increasing the flow of urine. The varieties of Dropsy in which the squill is thought to be the most useful are Aanasarca and Ascites. Digitalis is a medicine which possesses great power over the system, but which, although occasionally very beneficial, manifests its deleterious effects, and becomes decidedly injurious, if it be employed improperly or in excessive quantity. When we consider the nature of the primary action of squills and digitalis, we can scarcely suppose that they operate upon the same principle, yet as we are not able with any degree of precision to explain the nature of their operation, we are decided almost entirely by mere experience, in determining upon the individual cases for which they are each of them more peculiarly adapted. The variety of Dropsy called Hydrothorax, in which the cavity of the chest is the seat of the disease, has been generally conceived to be the one in which digitalis is most serviceable; and it is agreed that a languid, or, as it is metaphorically termed, a relaxed habit and a phlegmatic temperament, is better adapted for the exhibition of this medicine than a constitution of an opposite description. The supertartrate of potash has been spoken of by many respectable practitioners as a powerful diuretic; and there are other neutral salts, principally those into the composition of which the tartaric and acetic acids enter, which are generally supposed to possess the effect of promoting the action of the kidney, but they are all of uncertain operation. When they prove successful in increasing the quantity of the urine, they commonly, at the same time, act as purgatives; and it may be questioned whether they are to be considered as any thing more than mild hydragogues, the peculiar property of which is, to cause a copious watery discharge from the mucous surface of the intestines, in which the urinary organs may also partake. We have sufficient evidence of the effect of mercury as a diuretic, but it may probably be referred with more propriety to its operation as a general stimulant, than to any specific action upon the kidney: and this opinion appears to be countenanced by the fact, that the use of mercury in Dropsy is principally as an adjuvant to other substances, for example to squills and digitalis. If the hypothesis be not too mechanical, we may regard mercury as a stimulant to all the secretory organs, probably in proportion to their degree of vitality, or their connexion with the circulating system; but that its operation may be more particularly directed to any one of them, by being united with a medicine which acts specifically upon the part; of this we have an illustration in what we observe with respect to purgatives as well as diuretics. Perhaps the only cases in which we can consider mercury as having any direct effect in the removal of Dropsy, is where the disease depends upon the enlargement of some glandular part, either by the constitutional derangement as connected with the digestive organs, or merely by its mechanical pressure upon the great trunks of the absorbents; the power which mercury is conceived to possess in discussing glandular tumours, being independent of its action on the kidney. As to the second indication in the cure of Dropsy, to prevent the re-accumulation of the fluid after it has been removed, all that can be said on this point may be included in the single direction of adopting every means for improving the general health, we must avoid the exciting causes, and we must endeavour to strengthen the digestive organs by temperance, exercise, preserving an open state of the bowels, and by the proper exhibition of tonics.

After these general remarks on Dropsies, as constituting an order of diseases, we must proceed to make a few observations upon the different genera. Concerning Anasarca we have little to add to what has been said above, either as to its symptoms or its cure; for as it is the most universal in its seat, so it presents us with the fewest peculiarities with respect either to its symptoms or its treatment. Purgatives, exhibited according to the strength and constitution of the patient, of which the neutral salts and the hydragogues will probably be found the most appropriate, are sometimes alone able to effect the removal of the effusion. If these fail, we proceed to diuretics, of which squills, in combination with calomel, suggest themselves as the first to be tried. Along with these, or rather to complete the cure after they have accomplished their object, we must have recourse to the same kind of tonic treatment which is employed in other diseases, where the strength has been much reduced.

Ascites is a more formidable disease than Anasarca, as it generally depends upon a structural affection of some of the abdominal viscera, or upon a local derangement, which is out of the reach of medicine, or is connected with some other morbid condition of the system. The disease is characterized by distention of the abdomen, in which the fluctuation of a fluid may be distinctly perceived, and to this local symptom, which properly constitutes the disease, we have always considerable disturbance of the system generally, loss of appetite, and torpor of all the organs concerned in the function of digestion; the usual deficiency of urine occurs, and as the disease advances, the strength fails, the flesh wastes, and ultimately hectic, with complete atrophy, supervenes. Besides other causes of uneasiness, the patient suffers great distress from the mere bulk of the abdomen, which is often so large as materially to interfere with the various vital and organic functions, especially the respiration and the circulation. The fluid is usually effused in the general cavity of the peritoneum, but in some cases it is contained in a partial cyst; in these instances the constitutional symptoms are generally less urgent, as the affection may be supposed to proceed from some cause of a more local nature, which, at its commencement, has but little effect upon the system at large. It is indeed principally from the proportion which the general bears to the local symptoms, that we are to form our judgment respecting the seat of the effused fluid, whether it be encysted or not, a fact of some consequence in the treatment of the disease, and one of very great importance in its prognosis.

In treating Ascites, the only point to be considered, in addition to the general principles which we have laid down above, respects the propriety of discharging the water by an operation. Where the tumour is very large, and where it seems, by its mechanical bulk, to injure the action of any of the functions that are essential to life, we occasionally find it necessary to puncture the sac, but, for the most part, we derive little permanent benefit, and it would appear that we not unfrequently bring the disease more rapidly to a fatal termination. Ascites, when it proceeds from a structural disease of any of the abdominal viscera, which is one of its most frequent causes, can only be effectually treated by the employment of those remedies which act upon the diseased organ; and it must be confessed that, in these cases, our prospect of success is very limited. A cautious use of mercury, in combination with squills, is perhaps the best remedy that can be tried; but it will be often found ineffectual, and a variety of occurrences almost daily present themselves, which will demand our attention, and oblige us to swerve from any regular plan of treatment which we may wish to adopt.

Hydrothorax, or Dropsy of the chest, is characterized by difficulty of breathing, which is increased in the horizontal posture, by disturbed sleep, palpitation of the heart, irregularity of the pulse, and frequently by all the symptoms of general Dropsy. Sometimes, by certain motions of the body, or by certain postures, the presence of the fluid in the chest may be perceived by the patient himself, and it may be felt by the practitioner, when he employs a peculiar method of striking the chest, or pressing upon the contiguous parts. The immediate cause of Hydrothorax, like that of Ascites, is generally a disease of some of the viscera; and as, from its local situation, it is more connected with the functions which are essential to life, its prognosis is more unfavourable. It has been generally supposed that this species of Dropsy is more peculiarly adapted for the administration of digitalis than any other remedy; a circumstance which, if correct, may perhaps be explained by the power which this remedy possesses over the circulation. When we determine to prescribe this substance, it should always be done with the greatest caution; and if we do not find it to be useful after it has been taken for a short time, we are not to expect any benefit from the farther continuance of it; for were we to persevere, we should probably experience its deleterious effects. Purgatives are always indicated in Hydrothorax, and the operation of the various neutral salts, as being the least stimulating, and at the same time possessing the hydragogue property, we conceive to be the most appropriate. It may be doubted whether blisters or other remedies applied externally to the chest can be of any avail in this complaint; and with respect to the operation for discharging the fluid by an artificial opening, besides the objections that were urged against the analogous practice in Ascites, we have here the additional objection, that it is more difficult and painful, that it is less easy to ascertain the unequivocal existence of water in the chest, and that the subjects of Hydrothorax are more frequently persons advanced in life, of a bad habit of body, or debilitated by other diseases, and therefore less likely to derive any benefit from the discharge of the fluid, than many of the subjects of Ascites, so that, upon the whole, we should conceive, that it can only be under a very rare combination of circumstances that this operation should ever be recommended.

With respect to the other kinds of Dropsy, we have already given an account of Hydrocephalus among the diseases affecting the head; for although it may be correctly placed among the Hydropes in a nosological system, yet, in a pathological and practical point of view, it more properly comes under the Neuroses. The Hydrops pericardii is a disease, the existence of which it is difficult to ascertain before death, and for which we have no appropriate remedies, while the other genera that have been enumerated, so far as their treatment is concerned, fall under the province rather of the surgeon than of the physician.*

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* Dropsy is still a disease of frequent occurrence and lamentable fatality: the theories concerning its causes and nature have been as various and conjectural as the means proposed for its removal. Hence the most dissimilar articles of the materia medica have at different times been recommended as certain remedies for the cure of this disease, in its various forms. It seems consonant with our best views of the animal economy, both in health and in disease, to consider Dropsy, in a great majority of instances, as the result of an increased secretion of the serous fluid; and, in attempting its removal, due regard ought also to be paid to its character as a symptomatic, or as an original affection. In the text are enumerated the diuretics generally esteemed the most efficacious in the different varieties of dropsy; and of these remedies the scilla maritima, especially when united with mercury, claims a decided preference. It may be questioned whether, even in Hydrothorax, the digitalis can be administered for any length of time with advantage: in the other forms of Dropsy, experience warrants the conclusion that it has been the occasion of much mischief. When Dropsy is the result of plethora, and depends upon an increased exhalation, the lancet appears to be one of our most available resources, and, in this state of the system, the digitalis, administered temporally, may be of some advantage; but in the second stage of this disorder, when symptoms of fulness or of preternatural excitement do not exist, the use of the foxglove not only adds to the debility of the patient, but evidently aggravates the complaint. The theory of the curative action of mercury in Dropsy, stated above, is on the whole the most satisfactory. The elaterium might, with much propriety, have been mentioned among the number of the most powerful remedies in Dropsy. The late Dr. Ferriar has successfully shown, that it surpasses every other medicine in its power of removing serous accumulations, and in relieving dyspnœa arising from hydrothorax and ascites. He has briefly related the particulars of twenty cases, in which the elaterium was prescribed with various success.

"The sensible effects of the elaterium," says Dr. F "are severe and constant nausea, frequent watery stools, and, in considerable doses, vomiting It does not uniformly increase the urine, and for this reason it is generally proper to combine it with more certain diuretics. After continuing the use of the medicine for some days, the patient will sometimes bear a considerable increase of the dose. I have gone to the extent of five or six grains a day, in this manner, without producing any inconvenience. But it is always proper to begin with the lowest dose, which is the sixteenth part of a grain of the extract." Med. Hist. and Reflect. vol iv.

The writer of this note, from the observation and experience of several years, is convinced that the elaterium is entitled to the

Sect. X. *Cutaneous Diseases.*

We have made the various diseases of the skin the fourth order of the Paratrepses, an arrangement which we are induced to adopt, because we regard them as, for the most part, proceeding from, or depending upon, a morbid condition of the body, connected with a defect of some of the functions either directly or indirectly concerned in the process of nutrition. Some of them are, no doubt, entirely local in their origin, and remain so during the whole of their progress; but in the general view which we are now taking of the subject, it would not be practicable to attend to these minute distinctions, nor indeed is the limit between those that are strictly local, and such as exercise a more general operation over the body, drawn with that exactness, as to enable us, even with every degree of attention, to determine to which class many of the individuals may belong. In a nosological system, which is exclusively appropriated to the consideration of cutaneous affections, it is necessary to introduce every complaint of the skin, although it may appear to be only one symptom, and that perhaps the least important of a number of others that constitute the disease; but in a more general arrangement, we place many of the eruptions, as Small-pox, among the Exanthemata, or in other classes, according to the nature of the circumstance that gives their distinguishing character. In a practical point of view, the most perfect arrangement of cutaneous diseases would be derived, not so much from their visible form, whether they presented the appearance of pimples, vesicles, ulcers, &c. as from a combination of those circumstances which might throw light upon their seat, or their proximate cause. We are, however, altogether unable to accomplish this, except in a few instances, and therefore we must have recourse to a more technical method of classing them according to their external characters. The most scientific arrangement upon this principle, is that in which the cutaneous affections are distributed into eight genera, according as they essentially consist in pimples, scales, rashes, blebs, pustules, vesicles, tubercles, or spots. It would be obviously inconsistent with the nature and object of this work, to enter into a minute examination of all the various modifications which these diseases assume, or even to describe them individually in their more ordinary forms. Indeed, the management of them may almost be considered as a separate department of the art, like that of surgery, and as not falling under the cognizance of a general treatise on the practice of medicine. We shall, therefore, aim at nothing more than to offer a very few remarks, relative to the general principles upon which we treat these complaints, without descending to a separate enumeration of them.

In the first place, exclusive of those cutaneous diseases which essentially consist in Fever, and of which the eruption is only an accompanying symptom, such as Small-pox and Measles, we may consider them as belonging to the two great divisions of acute and chronic, or, what amounts nearly to the same thing, of such as are constitutional, and such as are local. The first of them come on suddenly, and produce some disturbance of the functions, and after running through a regular course, manifest a tendency to a spontaneous cure; the second come on gradually, continue for an indefinite length of time, disappear, and again make their appearance in an irregular manner, and this without necessarily producing any constitutional action, or being accompanied by any change in the state of the functions. A second important circumstance respecting cutaneous diseases is, whether they are contagious or not; the greatest part of them are certainly not so, but there are others which exhibit this property in the most marked manner, and which it is therefore necessary for us to guard against in our management of such cases. In the 3d place, some cutaneous diseases are obviously hereditary, the children of those who have been affected by them having a peculiar tendency to such affections. In the 4th place, different cutaneous diseases are observed to attach themselves especially to different periods of life, some being confined to childhood, others appearing more commonly about the period of puberty, and others again in old age. In the 5th place, the habits of life, especially with repect to exercise and temperance, the nature of the employment, local situation and climate, and many other circumstances, both external and internal, have a very powerful influence in the production of cutaneous diseases; and the same may be observed with respect to the state of society, and the degree of civilization, which, except in a few instances, where there has been too much indulgence in the luxurious gratifications of the palate, tends most materially to diminish the violence, or even altogether to annihilate some of the most loathsome of them. Independent of all these circumstances, there are causes which we are quite unable to comprehend, from the operation of which certain affections of the skin prevail at certain periods, and afterwards become nearly extinct, in this respect resembling various other classes of diseases, in which these alternations of increase and decline are not unfrequently observed, and which are equally difficult to refer to any assignable cause.

In the cure of cutaneous diseases, the first point to be attended to is, how far we are to employ general remedies, or how far we are to rest satisfied with mere topical applications. Probably, in a great majority of instances, they will both of them be necessary. There are, indeed, some of these affections which may be cured solely by topical remedies, while, on the contrary, there are others which require only constitutional treatment. The general remedies may be classed under the heads of those that tend to diminish febrile excitement, of purgatives, sudorifics, and tonics, to which we must add specifics, those which cure the disease without producing any sensible effect, which we can refer to a gene-

praises bestowed upon it by Dr. Feriar: it is a powerful and certain hydragogue, doubtless to be administered with caution. It may, with safety, be prescribed to the extent recommended in the preceding extract. A judicious and prudent course seems to be, to commence its use with the third of a grain, three or four times a day, and never exceeding two grains, three times a day. It may be united with small doses of cream of tartar or of calomel. In cases of extreme torpor of the intestinal canal, where the ordinary remedies have failed of their wonted effects, the writer has witnessed the complete success of the elaterium It is somewhat remarkable, that the able author of the text should have taken so singular a pathological view of Hydrocephalus, as to class it among the Neuroses.

Francis.

ral principle. In applying these remedies, we must obviously select them according to the supposed necessity of the case. We inquire whether there be any febrile excitement, any torpor of the bowels, dryness of the skin, defect of appetite, or general weakness, and we then use the appropriate remedies. The local remedies for cutaneous affections may be arranged under the heads of stimulants and sedatives, those which excite or diminish the action of the vessels of the skin; emollients, those which mechanically soften or relax the parts; and here also, as in the former case, we must introduce a class of specifics. Of the existence of a class of remedies, which have the power of stimulating the skin when applied to its surface, we have sufficient evidence; but there is considerably more difficulty in clearly distinguishing the action of sedatives; and when we wish to produce this effect, it is generally accomplished in an indirect manner, or simply by the removal of some stimulating cause. The circumstances which direct our judgment in the choice of remedies, are derived partly from inquiring whether the symptoms indicate an excess or a defect of action in the part, and partly by tracing an analogy between the disease under consideration, and others, with the treatment of which we are better acquainted,—a kind of practice, it must be confessed, which is often very empirical, and the result of which is very uncertain. Of this uncertainty we have the most convincing evidence in the writings of those, whose judgment and information on these topics is held in the highest estimation; for we find that they proceed principally upon the experience that is derived from insulated facts, and that they frequently recommend, for the cure of the same disease, remedies that appear to be of the most opposite nature, in the selection of which we have very little explicit direction, but are recommended to try them in succession, and to adhere to that which appears to be the most beneficial. Upon the whole, we may conclude, that whatever promotes the general health must be always favourable to the relief of these diseases, and in many cases will effect a cure; that, for this purpose, it is of the highest importance to obtain a healthy state of the digestive functions, and that temperance, fresh air, exercise, and purgatives, are to be regarded as the basis on which we are to proceed, and which will materially assist us in the future progress of the cure. Upon this principle, we shall be at no loss to account for the benefit that is obtained from purgative saline waters, and when they contain sulphur, which has a decided claim to be considered as a specific in certain cutaneous diseases, they present us with the most effectual remedy for some of these affections. Calomel has been very generally employed in these cases, and there can be no doubt of its frequently proving highly useful; but we should be disposed to refer its good effects to its action as a purgative, or at least to the power which it exercises over the organs that are concerned in the processes of digestion and assimilation. We have but little confidence in most of the boasted specifics for cutaneous diseases; they are generally given after the exhibition of more active remedies, if not in conjunction with them. Their operation, even as admitted by their advocates, is slow, and unattended with any sensible effects, and they are commonly prescribed in connexion with some system of regimen, or with some change in the occupation or mode of life, to which we may, with more probability, refer any advantage that is gained. We must, however, make an exception in favour of sulphur, of the efficacy of which no one can doubt, and the same remark may be also extended to arsenic, and probably to iron, but of the nature of their operation we do not presume to offer any opinion. As to the whole tribe of stimulants, both the various chemical preparations, acids, alkalies, metallic oxides, and salts, as well as the acid vegetable substances, we have little to observe in the way of general principles, how far any of them ought to be regarded as possessing specific virtues, or whether they differ from each other solely in the degree of their stimulating power, or in their mechanical properties, we do not feel competent to decide.

CHAP. V.

Pareccrises.

Sect. I. *Diarrhœa.*

We have placed the diseases of the secretory organs in a separate class, under the title of Pareccrises, and have divided them into the two orders of Apocenoses and Epischeses, according as they produce an excess or a defect in the quantity of the secreted fluid. In the first order we have the following genera, depending upon the organs which they immediately affect, Diarrhœa, Cholera, Hyperuresis, Blennorrhœa vesicæ, Lithiasis, Menorrhagia, Leucorrhœa, Ptyalismus, Ephidrosis. These diseases may be considered as, in a great measure, local in their origin, and during their progress are not essentially productive of any constitutional disturbance; they are not necessarily attended with fever, they have no effect upon the nervous system, except upon those parts of it with which they are in immediate contact, and they may frequently be removed by remedies that seem to act locally, or without the intervention of any organ besides that to which they are directly applied.

The first genus of this order is Diarrhœa, a very common disease, which consists in an increased discharge from the alimentary canal, the evacuations being but little affected, except in their assuming a more liquid consistence; they are generally preceded or accompanied by flatulence and a griping pain in the bowels, and frequently by sickness; but this should perhaps rather be attributed to the same cause which produces the Diarrhœa, than be considered as a part of the disease itself. The symptoms of this complaint are so obvious as seldom to leave any doubt respecting its existence; but there are two diseases that resemble it, and from which it is important to distinguish it, Dysentery and Cholera. For the most part an attention to the nature of the evacuations is sufficient to point out the distinction, or if, as occasionally happens, the diseases appear to run into each other, our remedies must be administered accordingly, always adapting them rather to the symptoms than to a technical nomenclature. The exciting causes of Diarrhœa are various; perhaps the most frequent is repletion of the stomach, or the reception into it of some kind of indigestible food; cold applied to the surface of the body, and especially to the legs and feet, is also an exciting cause of Diarrhœa; and it is occasionally produced by impressions upon the nervous system, or even by mere mental emotions. In children, the peculiar irritation produced by teething seems to be a frequent exciting cause of Diarrhœa, as well as that which arises from the presence of worms in the alimentary canal. Although the evacuations in Diarrhœa essentially consist of fæculent matter, they vary considerably in their appearance; and from observing these variations, we have it in our power, in some cases, to judge of the state of the parts which immediately give rise to it. Diarrhœa is often symptomatic of some other disease, many instances of which have been stated above; of these, one of the most violent is the colliquative discharge from the bowels which occurs in the latter stages of hectic fever. It is also a frequent attendant or sequel of the affections of the liver that come on after a residence in hot climates, and is then found to be one of the most unmanageable symptoms of these diseases.

In its simple form Diarrhœa is not difficult of cure, and, perhaps, in a great majority of cases, would be relieved by the mere efforts of nature, as it is a complaint for which a direct remedy is provided in the constitution of the living body, so as to afford one of the strongest arguments in favour of the doctrine, which was once so generally adopted, that all diseases are salutary efforts of the system, expressly intended to ward off some greater danger, which they effect without the intervention of art. In most cases, however, the aid of medicine may be advantageously had recourse to, either to mitigate the violence of the disease, or to prevent it from degenerating into some affection of a more injurious tendency. The obvious indications are, first to remove the exciting cause, if it still remains applied; and, 2dly, to obviate that state of the system which is induced by the immediate action of the complaint.

The proximate cause of Diarrhœa appears to be an increase of the peristaltic motion of the intestines, which may depend either upon a stimulating substance applied to them, or upon an increased sensibility in the part, rendering it more easily affected by the ordinary stimuli. When the disease depends upon the first of these causes, there can be no doubt of the method to be followed in the cure; and as cases of this description constitute a great majority of those that fall under our observation, we shall generally find it necessary to direct our chief attention to this object. For this purpose we shall find the most effectual remedies to be mild purgatives, given in small doses, and frequently repeated, by which the offending matter is discharged more effectually, and with less pain and distress to the system, than if left to act upon the part without assistance. Along with the purgatives large quantities of mild diluents will be found serviceable; and the food should be of the least stimulating kind, and be composed as much as possible of liquids. The choice of the purgative will depend upon the state of the stomach, and various other circumstances; neutral salts, castor oil, rhubarb, and magnesia, are perhaps among those that are the most generally applicable; the last will be especially proper when we have reason to suspect an acid state of the alimentary canal. After the due exhibition of purgatives, we shall generally find the complaint to subside without the use of any other remedies; and, by a proper regulation of the diet, the parts resume their healthy action. Occasionally, however, the Diarrhœa continues after all the offending matter seems to be removed, and the digestive process remains much impaired, while the patient is, at the same time, harassed with griping pains and flatulence. Under these circumstances, we have recourse to astringents and tonics, together with the occasional use of sudorifics and opiates. The employment of astringents in Diarrhœa we do not, however, conceive to be very frequently necessary; and it is found, both with respect to the class of remedies and to opium, that if they do not check the complaint by the exhibition of a few doses, no considerable benefit is to be expected from them. The valuable compound of opium and ipecacuanha, which we have so frequently referred to under the title of Dover's powder, is a very useful remedy in long protracted Diarrhœa, especially when in conjunction or alternating with purgatives. Considerable advantage has been gained by the use of warm clothing, and particularly of flannel worn next to the skin, in those who are subject to frequent attacks of Diarrhœa; and sometimes it has appeared that the warm bath, or even the removal to a milder climate, has been of permanent utility.

Sect. II. *Cholera.*

Cholera consists in the vomiting and purging of bilious matter, attended with painful griping, and with cramps of the legs. It is sometimes difficult to draw the line between this disease and Diarrhœa, although, when it exists in an acute state, it is easily distinguished by the nature of the evacuations. It seldom occurs in this country, except in the autumnal months, and it is then found to be the most prevalent in the hottest seasons; but is generally observed to come on rather after the period of the greatest heat than during its continuance.

The leading symptoms of the disease seem to mark it as arising from some peculiar condition of the bile, and the time of its invasion favours the idea, that external temperature has an important influence in its production; but we are scarcely able to explain the nature of the connexion between these circumstances, or to shew in what manner the heat of the weather produces the change in the state of the bile, or indeed what is the exact nature of the change which it experiences. Cholera is a violent disease, and one which is very rapid in its progress; reducing the patient in the space of a few hours to a great degree of debility, and, if not checked by the appropriate remedies, proving suddenly fatal.

Its cure is to be effected, by completely evacuating the intestinal canal of the irritating matter which appears to be the exciting cause of the disease, and this is generally accomplished merely by the exhibition of mild diluents, which may be taken as copiously as the stomach will receive them. When the acrid bile has been entirely removed, we then endeavour to allay the irritation by opiates, and afterwards to recruit the exhausted powers of the system by gentle stimulants and excitants. To allay the griping pains fomentations may be applied to the abdomen, and sometimes immersion in warm water will be found highly grateful to the feelings of the patient, when it can be commodiously applied. After the violence of the disease has subsided, the patient is left in a state of great weakness and langour; but by the proper regulation of the diet, and by avoiding all unnecessary causes of excitement, the strength is generally restored with more rapidity than might have been imagined from the degree of exhaustion. Bitters and tonics of various kinds are generally administered for the purpose of strengthening the digestive powers, and of these colombo is the one which is found to be the most useful.

Sect. III. *Lithiasis. Stone.*

We have placed calculous complaints as forming a genus under the order of the Apocenoses, because they depend upon the formation of certain substances in the urinary organs, which originate, in the first instance, from an irregularity in the action of the secretory vessels of the part. The disease is characterized by uneasiness in the region of the kidney, the bladder, or some of the passages connected with them; by a difficulty and pain in passing the urine; frequently by a deposition of calculous matter from this fluid; or by the presence of a calculus in the bladder, as ascertained by the introduction of the sound.

The exciting or predisposing cause of the disease is probably, in all cases, a derangement of the digestive organs, by which the fluids undergo some change in their nature, so that, in passing through the kidney, certain substances are secreted that concrete together into solid masses. These, according to their form, and the situation where they are deposited, produce various distressing symptoms, that are immediately to be attributed to their mechanical bulk, either pressing upon the contiguous parts, or obstructing the discharge of the natural excretions. Very minute attention has been paid of late years to the chemical analysis of urinary calculi; and, according to the most accurate experiments, we may arrange them under the following heads: 1st, The lithic calculus; 2d, The bone earth calculus, consisting principally of phosphate of lime; 3d, The ammoniaco-magnesian phosphate; 4th, The fusible calculus, consisting of a mixture of the two former; 5th, The mulberry calculus, composed of oxalate of lime; 6th, The cystic, consisting of the peculiar substance called cystic oxide. To these we may add the alternating calculi, those that are formed of different substances arranged in alternate layers; and the compound calculi, composed of different ingredients mixed together without any regular order.

As urinary calculi are properly extraneous bodies, and do not possess any vital properties, it has been always considered a most important point to discover some chemical agent, by which they might be rendered soluble, and in this way discharged along with the urine. Until very lately all the attempts that had been made of this kind were entirely empirical, and, notwithstanding various flattering accounts which, from time to time, had been laid before the public, were altogether abortive; but since the greater accuracy of modern chemistry, their nature has been thoroughly investigated, and we are well accquainted with means by which most of them may be readily dissolved out of the body. It still, however, remains a doubtful point, whether, while they are in the bladder or the urinary passages, any re-agent taken into the stomach can be carried along the circulation so far, unaltered, as to be capable of acting upon the calculus through the intervention of the urine; and, upon the whole, we are disposed to think that but little can be expected from this mode of proceeding. But, although we may fail in this object, there are still two methods of relieving the disease; one indeed, which is extremely painful, and after all merely palliative, viz. by cutting into the bladder, and removing the calculus; the ether, which, if it can be accomplished, must be regarded as the more desirable plan, is by counteracting that state of the digestive organs which gives rise to the disease. Upon the whole we may conclude, with respect to this latter point, that whatever remedies would, in other circumstances, tend to improve the process of digestion, and establish the healthy action of the intestinal canal, will be equally serviceable in preventing the formation of calculi. But, besides this general view of the subject, it will be necessary for us to examine the state of the urine in the individual cases of Lithiasis that present themselves; because in most of them we can distinctly perceive the existence of two conditions of the system, which are very different from each other, produce different effects, and may probably require different remedies. In one of these a calculus is formed of an acid nature, which it may therefore be supposed will require alkaline medicines for its prevention; while in others there is a tendency to the formation of a calculus in which an alkaline earth predominates, and which may therefore be supposed to indicate the employment of acids for its prevention. Upon this principle, we have been directed, in the treatment of Lithiasis, first to examine into the state of the urine, and into the nature of the calculous deposition, or of any solid matter which may have been discharged, and to administer either the carbonates of the fixed alkalies, or diluted muriatc acid, according to the result of the examination. Besides these, we are to give purgatives freely; to enjoin a plain diet, especially abstaining from fermented and spiritous liquors; and, in short, to adopt that system of regimen which is the best calculated to induce a healthy action of the stomach and bowels—a circumstance which we are inclined to think is much more important than any direct chemical effect that can be produced on the fluids. The propriety of an operation will depend upon the urgency of the pain, or the other symptoms arising from the mechanical bulk of the stone. We shall only remark, that sometimes a large calculus in the bladder may be borne with tolerable ease, when, by the use of the proper remedies, it can be prevented from increasing in size; this probably arises from its more prominent and irritating parts being rounded off, and the organ becoming accommodated to its reception.

Sect. IV. *Leucorrhœa.*

We have placed Menorrhagia among the Apocenoses, because there is reason to suppose that the menstrual discharge is, strictly speaking, a secretion; owing, however, to the nature of its symptoms and treatment, we have enumerated it among the Hæmorrhagies, and have given directions for its management in that part of our system. Leucorrhœa, which consists in an increased secretion from the mucous glands of the uterus, is characterized by the appearance of the discharge; by pain in the loins; loss of appetite; general debility; and wasting of the flesh. The discharge is sometimes of so acrid a nature as to excoriate the parts on which it lodges, and occasionally it even communicates the same symptoms by contact to a second person.

It is not very easy to ascertain either the exciting or the proximate causes of Leucorrhœa. Whatever stimulates the parts in an excessive degree has been conceived to give rise to the complaint; but, on the other hand, it has also been attributed to a variety of circumstances that tend to debilitate the system. Perhaps we ought to ascribe the affection to general debility, combined with local excitement. The debilitating effect of the complaint is much greater than might have been expected from the quantity of matter discharged, indicating that the complaint is to be referred chiefly to some constitutional action, depending upon the relation which the uterine system bears to the other parts of the animal economy. The complaint is often sympathetic of some structural disease of the uterus, and is then more unfavourable in its prognosis, and often more distressing in its immediate effects; but when it exists in its simple form, although, as we have remarked above, it is considerably debilitating, and proves a source of much inconvenience, it is seldom to be regarded as dangerous.

The indications of cure are not very obvious, and the effect of remedies is uncertain. The usual method has been to employ tonics and stimulants; but we are frequently disappointed in our expectations of benefit from them, and, under certain circumstances it would appear, that the opposite plan of treatment is more successful. We occasionally derive advantage from the topical application of astringents, such as solutions of tan, alum, or sulphate of zinc; but it may be doubted, whether the effect of these substances, as essentially consisting of cold fluids, is not as powerful as any specific operation derived from the nature of their ingredients. Cantharides have lately been recommended in Leucorrhœa, both taken internally, and applied externally in the form of blisters, to the parts contiguous to the uterus; but it may be doubted how far they will be found to correspond with the high character that has been given of them. As there is generally a torpor of the intestines, it is obviously necessary to employ purgatives; and it is supposed that some particular benefit is obtained from those that are of a stimulating nature, as the resins and extracts, but we are disposed to doubt the correctness of this opinion. Violent exercise of all kinds appears to be injurious; and we should avoid all those circumstances which excite the circulation without increasing the strength of the system, such as stimulating liquors, luxurious diet, and heated apartments.

Sect. V. *Icterus. Jaundice.*

The second order of the Parecrises consists of the Epischeses, those diseases in which there is a deficiency of some of the secretions and excretions. The first genus of this order is Obstipatio, an affection which is generally symptomatic of some derangement of the stomach, the liver, or other viscus concerned in the process of digestion, but which may depend upon a torpor of the intestinal canal itself, and which is then to be obviated by the regular exhibition of purgatives, in the selection of which we must be guided more by the particular circumstances of the case, than by any general rules that can be laid down upon the subject. The operation of these remedies is always much promoted by an attention to diet, pure air, and exercise.

We have placed Icterus in the same order, although it probably, in some cases, at least, depends rather upon the retention of bile, than a deficient secretion of it, a defect which generally happens in consequence of some obstruction in the passages through which the fluid descends, in the natural state of the parts, into the duodenum. The most remarkable symptoms of Jaundice depend upon the absorption of bile into the circulation after it had been previously secreted; upon this depends the peculiar colour of the skin and the cornea, arising from the serum of the blood being tinged with bile, which is carried into it by the lymphatics of the liver. To the same cause, the bile being actually present in the blood, we may ascribe the bitter taste of the saliva, and the yellow colour which is communicated to the urine, as well as its property of dyeing substances that are immersed in it. The bile being thus diverted from its natural course, the deficiency of it in the intestines produces a train of symptoms in the digestive organs; the fæces become whitish, or of a clayey appearance, and the bowels torpid; while the appetite fails, and the whole process of digestion and assimilation is deranged. There is also pain in the region of the liver, and the patient experiences an unusual degree of lassitude and general weakness. In what way the phenomena of Jaundice are connected together, whether a mere obstruction to the passage of the bile from the liver to the intestines is the primary cause of all the other symptoms, whether there is some original defect in the secretion of the bile itself, or some torpor in the digestive organs or their appendages, may be doubted; nor, supposing it proved that the disease proceeds from a mechanical cause, are we able to determine how the deficiency of bile in the intestinal canal can produce the effects that we observe on the digestive process. In many cases Jaundice evidently depends upon some disease in the structure of the liver, by which its functions are permanently injured, sometimes by an extraneous body filling up the duct, or pressing upon it; but there are cases in which, so far as we can judge, it appears to arise from some cause that is more strictly idiopathic, and of a less mechanical nature.

In the cure of this complaint, we are first to ascertain whether it depends upon a scirrhus of the liver, or any other structural disease of this organ, in which case our remedies must be obviously directed to this circumstance. If we suspect it to arise from a mere mechanical obstruction, we generally have recourse to purgatives; and these remedies are probably the best that we can employ in Jaundice that is more strictly idiopathic. The more active purgatives are usually found to be the most efficacious, and it is generally thought desirable to combine them with calomel. An emetic is often indicated by the state of the stomach; and by this remedy we not only free this organ from its load of oppressive contents, but it appears that the agitation which is produced by the act of vomiting occasionally removes obstructions from the ducts of the liver. The disease is sometimes attended with very acute pain, for which opiates are necessary; and besides the immediate relief which they afford, they sometimes tend to the radical cure of the complaint, by relieving certain spasmodic contractions of the parts which aggravate the disease, by increasing the obstruction to the passage of the bile along its natural channels. After the disease itself has been subdued, the impaired state of the digestion often renders it necessary for us to have recourse to stomachics and tonics, of which colombo appears to be the most useful. Considerable benefit is sometimes produced by a long continued employment of the saline mineral waters, to which the fresh air and exercise which form a part of the usual regimen in such cases will materially contribute.

One of the causes of Jaundice, depending upon a mechanical obstruction to the passage of the bile, is the formation of the peculiar bodies called biliary calculi, giving rise to the disease of Cholelithia or Gallstone, a disease which properly belongs to the order of the Apocenoses, but the consideration of which we have deferred to this place, on account of its connexion with Jaundice. These substances are partly composed of inspissated and hardened bile, and partly of a crystalline animal matter, which concretes into rounded masses, formed in concentric layers, and possessed of specific chemical properties. In what way they are generated, or what particular states of the liver and its secretions are favourable to their production, is not ascertained, nor are we acquainted with any method by which their formation can be prevented. When they are impacted in the ducts of the liver, they cause very acute pain, which is generally referred to the pit of the stomach, and is often attended with severe vomiting, and by this operation the obstruction is occasionally removed; the same effect is sometimes produced by brisk purgatives. Opium and warm fomentations relieve the pain, and likewise the spasmodic contractions, which, as was remarked above, seem to exist in these cases, and tend to aggravate the complaint. There are instances in which the distention produced by Gallstones is so great as to produce inflammation, when bleeding must obviously be had recourse to, at the same time that we may try the warm bath and emollient injections.

Sect. VI. *Amenorrhœa.*

Ischuria, or a difficulty in the excretion of the urine, is perhaps in all cases a symptomatic affection, either occurring in connexion with some other more general disease, as Dropsy, or depending upon some obvious mechanical obstruction, as in Lithiasis. We shall therefore pass on to Amenorrhœa, or the deficiency of the menstrual discharge. It occurs under two forms, that of retention and of suppression: the first, where the discharge does not make its appearance at the proper period of life; the second, where, after it has appeared, it does not return at the usual intervals. There is another affection which ought perhaps to be regarded as a mere variety of Amenorrhœa, in which the discharge takes place at the proper times, but is in small quantity, and is attended with considerable pain: this has received the name of Dysmenorrhœa. When Amenorrhœa, in any of its forms, has continued for some time, it produces various constitutional derangements; there are pains in different parts of the body, especially in the neighbourhood of the uterus; the appetite fails, the bowels are torpid, the head is oppressed, Anasarca supervenes, the breathing is short, the pulse is weak, and the whole body becomes languid and enfeebled. In some cases, particularly in those where the discharge does not take place at the proper age, there is a remarkable sallowness of the complexion, from which circumstance the disease has obtained the name of Chlorosis; it is likewise attended with a singular tendency in the patient to take into the stomach various articles of an indigestible nature, which would seem to be the mere effect of caprice, did we not observe this morbid appetite to exist, where we have no reason to suspect this disposition from any other circumstance, and where the stomach is evidently in an unnatural state. The proximate cause of these complaints is evidently, in the first instance, the same, a defect of power in the vessels of the uterus, by which they are unable to propel the blood into the capillaries with due force and in the proper quantity. In what way this condition of the capillary vessels produces the general symptoms is perhaps not easy to explain; and indeed it may be suspected, that, at least in a great number of cases, the peculiar state of the uterus is rather the effect than the cause of the constitutional irregularity.

But whatever may be our determination upon this point, it does not affect the principles upon which we proceed in our treatment of Amenorrhœa, which is to excite the system generally, and the uterus in particular, by the use of those means which may increase the action of the arterial system, and especially of the uterine vessels. The state of the bowels obviously requires purgatives, and those of a stimulating kind; such as the resins and more acrid extracts, scammony, aloes, colocynth, &c. The degree of flatulence which is generally present, indicates the employment of what have been termed carminatives; and when there is much pain or irregular action of the parts, we may prescribe antispasmodics, of which perhaps the most efficacious is asafœtida, with an occasional opiate. Exercise, and especially horse-exercise, as much as can be borne without exhaustion, is a necessary part of the regimen; and the diet should be as nutritive as the patient can bear, without inducing indigestion or any degree of febrile excitement. We have hitherto taken no notice of that class of remedies that are styled emmenagogues, because we are extremely doubtful whether there be any to which this title ought to be applied, except to some substances, the action of which is so violent as not to be admissible into practice; we consider the savine to be of this description. Perhaps there is nothing which is better entitled to the specific appellation of an emmenagogue than electricity, and this application may be safely tried in conjunction with purgatives, and the other treatment that has been mentioned above. The warm hip-bath, or even warm water applied to the feet, frictions with the flesh-brush, and warm clothing, are generally thought to be serviceable. Besides these remedies, which appear to be more particularly indicated by particular symptoms, we often find it necessary to use stimulants and tonics, as the various kinds of bitters, and the preparations of iron; with respect to the latter medicine, it should not be employed until the bowels are rendered completely soluble, and in all cases it may be proper to combine it with aloes, or with some of the purgative resins or extracts.

CHAP. VI.

Paramorphiæ. Local Structural Diseases.

Having now, in our five first classes, gone through the different diseases which proceed from primary affections of the systems of the blood-vessels and the nerves, the mental faculties, the organs of nutrition, and those of secretion, we now come to the diseases which are of local origin. These form the two classes of the Paramorphiæ and the Ectopiæ; the first denoting a morbid change of structure, the latter a mechanal displacement of the parts concerned. The greatest number of these diseases fall under the province of surgery; they frequently require the assistance of some manual operation, or of external applications; and although they are often accompanied by constitutional affections, yet these are obviously sympathetic, so that our main attention is to be directed to the topical derangement.

We have divided our class of Paramorphiæ into Phymata and Phtharmata; the first including tumours of all descriptions; the second denoting an alteration in the substance or structure of the part, as where a membrane is converted into a bone, where a soft part becomes rigid, or a hard part becomes soft and flexible. Of the different genera which compose this order, perhaps the only one which can properly be considered as falling under the province of the physician, is that which consists of the organic affections of the heart. Besides the inflammation of this viscus, which has been already treated of among the Phlegmasiæ, it is subject to many other organic derangements; its valves, and their appendages, which are subservient to the mechanism of the circulation, are liable to become ossified, and its large arterial trunks are subject to the same affection. Sometimes, without assuming the bony texture, the membranous parts become rigid and inelastic; sometimes, on the contrary, the muscles that compose the substance of the heart appear to lose their tone or contractile power, and are relaxed, so as to admit of the ventricles becoming distended to an enormous size, and besides these, there are different kinds of mal-conformation in the original construction of the heart, which interfere with the performance of its appropriate functions. The symptoms that are produced are very various, and often are difficult to be accounted for; they seldom enable us to predict in what state the parts will be found after death, and even when we have ascertained this point by dissection, it is not always easy to reconcile the symptoms with the actual disease. A very remarkable circumstance respecting diseases of the heart, is the disproportion between the violence of the symptoms produced, and the actual alteration in the organ; even in inflammation, which has been so acute as to induce suppuration, and finally to prove fatal, that state has frequently not been previously indicated by pain in the part, or even by the state of the pulse. We have already had occasion to remark, that the disease of Angina Pectoris is frequently, if not in every instance, combined with a structural derangement of the valves, orifices, or great vascular trunks contiguous to the heart; and we have reason to believe that many affections, which are referred to the lungs or the stomach, originate from the same cause. It must be obvious that the cure of these diseases is, for the most part, beyond the reach of the medical art, and that in most of them we are not able to do much even in palliating their effects. The only general principle upon which we can proceed is, to endeavour to moderate the force of the circulation without weakening the vital powers; by avoiding violent exercise and sudden motion, by a strict plan of temperance, by keeping the mind in a tranquil state, and, in short, by preserving as uniform a degree of motion as possible in the parts concerned in the propulsion of the blood. Unless there should be any peculiar excitement, bleeding is not indicated, nor are purgatives adviseable as a general practice, unless there be an obstruction in the bowels, or some feeling of indigestion; for we may remark, that in order to prevent a plethoric state of the system, it is much more desirable to avoid repletion of the stomach, than to endeavour to obviate its effects. Blisters and issues applied to the chest have been found useful in relieving affections that have certainly seemed to proceed from an organic disease of the heart, and it will therefore be proper to try their effect. As it is so difficult to substantiate the existence of these complaints, we are, for the most part, reduced to the necessity of prescribing for particular symptoms; and although in this way we can expect to do little more than palliate, it must be admitted that very unexpected cures have occasionally resulted. Cases have sometimes occurred, where every circumstance seemed to indicate a serious organic affection, but where, by the exhibition of some medicines that improved the state of the stomach, all the alarming symptoms have vanished, and the patient has regained a state of perfect health.

With these observations we shall conclude the sketch that we proposed to offer of the principles of medicine. In a work expressly intended for general perusal, we have abstained from entering into minute details, convinced, as we are, that popular treatises of practical medicine are seldom useful and often dangerous. We have endeavoured to produce a work which may mark the present state of medical science, and which may serve as a basis for those who are desirous of entering more minutely into the subject. We have given a concise view of most of the doctrines which have either produced any considerable effect upon the state of medical practice, or which, from their real merits, seem to be entitled to our attention. If on many points we have dissented from the opinion of our predecessors, our apology must be that they, in their day, dissented as much from those who went before them; and if it be objected that we have frequently confessed the insufficiency of our art, and have left many formidable diseases without indicating an effectual mode of treatment, we may reply, that the science of medicine would probably have attained a greater degree of perfection, if writers had more strictly confined themselves within the limits of experience and correct deduction, and had not thought it incumbent upon them to point out a remedy for every disease. (α)

☞ The Numbers in the Index above 704, refer to Vol. XII. and those below 44, to the present Volume.

INDEX.

MEDINA en Nebi, a city of Arabia, in the district of El Hedjaz, or the *land of Pilgrimage*, which comprehends the *Arabia Petræa* of the Ancients, but beyond the confines of the Beled el Haram, or *holy land of Islam*, a territory that none, excepting Mahometans, are allowed to enter. This city stands on a fertile spot, in a mountainous desert. The mountains, which constitute a prominent feature in the whole land of Pilgrimage, are highest in its vicinity. Water is scarce throughout the territory, being obtained from a few inconsiderable springs and deep wells; but here and at Mecca the rain water is preserved by the inhabitants in cisterns, and the neighbouring gardens and plantations are supplied plentifully with it. The tree yielding the real balsam of Mecca, which is called *belsan*, grows in the surrounding desert, though it is not obtained at Mecca itself.

Medina is small, and surrounded by a slight wall, which seems to have been strengthened when the inhabitants were menaced by an army of sectaries a few years ago. It is a place of no importance, except from containing the sepulchre of Mahomet, the approach to which was always strictly interdicted to Jews and Christians; but the inhabitants enjoy the privilege of exemption from the impost paid to the scheriff of Mecca, the natural lord of the country, and the tenth exacted by the sectaries now alluded to. The Turkish emperor claims the sovereignty of Medina and the neighbouring territory, and had two officers in the city; but the scheriff of Mecca, enjoying an independent power, held the real supremacy, and had a vizir in Medina.

The tomb of Mahomet is inclosed by an iron grating within the precincts of a mosque of indifferent structure, and is surrounded by a rich brocade in letters of gold, on a green ground, the colour of the faithful. Neither the tomb nor the mosque are distinguished by any magnificence; but an immense treasure had accumulated for ages, the pearls and precious stones in which exceeded all estimation. Near to the tomb is seen an opening, which the Mahometans affirm is for the purpose of receiving Jesus Christ, as they believe he is yet to return, and die at Medina. Here also are the tombs of the Caliph Othman, and other friends or descendants of the prophet; and the chair or pulpit from which he was accustomed to preach, is yet preserved with superstitious care, to be used at festivals. A fable was formerly prevalent, that the tomb was suspended in the air between two magnets, or without any visible support. Poncet, a French physician, who designed visiting Medina about the year 1700, and travelled much in the East, declares that he visited a monastery of Abyssinia, for the purpose of seeing a similar phenomenon. There he beheld a round golden staff, about four feet long, suspended in the air; and, to detect any artifice, he requested the abbot to permit his examining more narrowly whether there was not some invisible prop or support. "For my better assurance," says he, "and to take away all doubt, I passed my cane over it, and under it, and on all sides, and found that this staff of gold did truly hang of itself in the air." It is not improbable, therefore, that some deception was practised in suspending this celebrated sepulchre, which those who determine on accounting for every thing conceived was accomplished by magnets. The tomb was enclosed by the iron grating, and was also guarded by 40 eunuchs, in consequence, it is commonly believed, of an attempt to carry off the bones of the prophet.

Medina and Mecca are two places of pilgrimage, resorting to which confers great distinction on the devout Mahometans; but it appears that the latter is more frequented. Nevertheless, a caravan annually repairs to Medina from Damascus, the principal purpose of which is to carry a rich carpet from the Turkish emperor for the tomb of the prophet. It travels under the direction of the pacha of that city, as prince of the pilgrims, is guarded by troops and artillery, and accompanied by a great number of women.

Of later years, both the religious and political state of Medina underwent an important alteration; nor can its condition at the present time be precisely ascertained. The environs of the city gave birth to a Mahometan sheik, named Abdoulwehhab, about the year 1720, who, after pursuing his studies here, contemplated great innovations on certain principles of the Musselman faith. But finding Medina itself unsuitable to his views, he left it to make a proselyte of Ibn Saaoud, prince of the Arabs, whose son Abdelaaziz endeavoured, in succeeding years, to subdue all the neighbouring countries. The Scheriff of Mecca, unable to resist his forces, retired to Medina in 1802; but the city proving untenable, he again withdrew. However, it withstood a body of troops sent from Mecca, which had been pillaged previously, and their commander Saaoud was obliged to retreat to Draaija, the capital of the sectaries, seventeen days journey east of Medina. But Saaoud having renewed the attack after his father had been assassinated in 1803, rendered himself master of Medina in 1804, where his followers shut and sealed the doors of the temple, destroyed all the ornaments of the sepulchre, and took possession of the vast treasures which superstition had accumulated. In 1805, the great caravan from Damascus obtained access to the city only by means of heavy sacrifices; and the reformers signified to the pasha, that in future it should come no longer under protection of the Turks, or accompanied by troops, trophies, music, or women, but that it should consist of pilgrims exclusively. The caravan having attempted to travel thither next year, without strictly conforming to these injunctions, had hardly reached the gates of Medina when it was obliged to retire in disorder, persecuted and annoyed by the sectaries. Devotion to the person of the prophet being prohibited as sinful, the reformers refrain from visiting his tomb; and they have destroyed the sepulchres, chapels, and temples erected in honour of saints. In the year 1807, the whole priests, servants, and slaves belonging to the mosque of Mahomet's tomb at Medina, were commanded instantly to quit the city, as also all pilgrims and soldiers, together with the Turkish judge. A complete revolution, both religious and political, was thus accomplished; but we have understood, that in the year 1817 or 1818 the Emperor of Turkey, in order to regain his influence in Arabia, sent a large military force against the reformers, by which they were defeated, and their leader, being taken prisoner, was carried to Constantinople, and there put to death. Lat. 24° North, Long. 40° 10′ East. 240 miles north of Mecca. (*c*)

MEDITERRANEAN Sea, is the largest inland sea in the world, forming the southern limit of nearly the whole of Europe. It is about 2000 miles long from east to west, and has an average breadth of from 400 to 500 miles. From the Bosphorus a strong current sets into the Mediterranean; at the Straits of Gibraltar another current flows in from the Atlantic; two weaker currents flowing outwards along the northern and southern shores. The tides in the Mediterranean are very small and irregular.

Dr. Marcet has lately shewn, that the water of the Mediterranean contains rather more salt than the ocean. This fact has been explained, upon the supposition that the Mediterranean is not supplied by the rivers which flow into it with a quantity of fresh water sufficient to replace what it loses by evaporation under a burning sun, aided by a powerful radiation from the African shores, and the parching winds blowing from the adjacent deserts. Philosophers have, therefore, attempted to explain why this sea does not gradually increase in saltness, and indeed be ultimately converted into saturated brine. This has been ascribed to an under current of water, salter than the ocean, which runs out at the Straits of Gibraltar, and unloads its waters of their excess of salt. This idea of a submarine current is countenanced by the fact communicated to Dr. Marcet by Dr. Carmichael, on the authority of the British consul at Valentia, that some years ago a vessel was lost at Ceuta, on the African coast, and its wreck afterwards thrown up at Tariffa, on the European shore, fully two miles west of Ceuta.

A similar fact is stated by Dr. Hudson. "In 1712, M. de L'Aigle, of the Phœnix of Marseilles, giving chace near Ceuta Point to a Dutch ship, came up with her in the middle of the Gut, between Tariffa and Tangier, and then gave her one broadside, which sunk her. A few days after the sunk ship, with her cargo of brandy and oil, came on shore near Tangier, at least four leagues to the west of the place where she sunk, and directly against the strength of the current; which has persuaded many men that there is a *recurrency in the deep water in the middle of the Gut, that sets outward to the grand ocean, which this accident very much demonstrates.*" *Phil. Trans.* 1724, vol. xxxiii. p. 192. See also *Phil. Trans.* 1819, p. 177; and *Edinburgh Philosophical Journal*, vol. i. p. 236, and vol. ii. p. 358.

MEDWAY. See England, and Kent.

MEKRAN, or Mecran, is a province of Persia, stretching from Cape Jask to the frontiers of Scind, along the Indian Ocean, which bounds it on the south. On the north it is bounded by Seistan and Arokaje; on the east by Scind; and on the west and north-west by Kerman. Mekran is divided by a range of mountains running from east to west. The northern part has got the name of *Balouchistan*. To the east there is a small independent state called *Lus*. Balouchistan is again subdivided into the seven following provinces or districts: *Jhalawan*, the most southern, and *Sarawan*, the most northern, both of which are extremely mountainous, and in general barren, though some of the vallies are capable of high cultivation, and produce, in favourable seasons, very abundant crops.—*Cutch Gandava*, which is about 150 miles long, and 40 or 50 broad, is chiefly low country, having a rich black loam soil, and producing all sorts of grain, besides cotton, indigo, and madder.—*Anund Dejel*, to the northward of the former, whose climate and soil are excellent.—*Shal* and *Muslung*, which are of very inconsiderable extent, but distinguished for the excellence and cheapness of their productions; and *Zuhree*, which is well peopled, and has the name of being the most civilized district of Balouchistan.

The province or district of *Lus* is of a circular form, and nearly surrounded by mountains, which separate it from western *Mekran*, *Balouchistan*, and *Scind*. The country itself is flat and sandy, and remarkably fertile in every description of grain. It has two small rivers, *Wudd* and *Pooralee*, (the ancient Arabius,) which, rising in the mountains near Bayla, falls into the ocean at Sonmeany, the principal sea-port of Lus. In order to obtain water, the inhabitants of this district, who are chiefly fishers, are obliged to dig holes in the sand, and having taken a supply, they fill them up immediately, lest the water should become salt, which it certainly does when the holes are left open.

Punjgoor, or *Punger*, which is remarkable for its dates, is a small, fertile, and well peopled district. It lies at the distance of about ten days journey, in a direction north north-east from Kej, the capital of Mekran, the whole of the mountainous tracts to the westward forming the southern boundary of the sandy desert, and on the parallel of Punjgoor. It has obtained the general name of *Wushutee*, or *Mecch*. Nooshky is a small sandy barren district, occupying an area of about 36 square miles, whose inhabitants subsist chiefly by plunder. Gurmsyl is also a very small but extremely fertile district, and is about five days journey to the north-west of Noosky. It is a narrow strip, in some places frequently not exceeding half a mile in breadth, and being flanked on both sides with high banks, it resembles the dry bed of a river. It derives its extraordinary fertility from the annual overflowing of the river *Heermund*.

Some of the districts in this province are almost entirely mountainous. The northern and southern parts of Balouchistan are described as a confused mass of tremendous hills, extending in length about 350 miles, but varying considerably in breadth; and the small state of Lus is bounded on three sides by one stupendous chain. In Western Mekran, the mountains run parallel with the shore, at the distance of eight or ten miles. At Chobar, however, and Cape Jask, they approach the coast. This chain attains its greatest elevation at Surku, the streams on the north side flowing towards the Persian Gulf, and those on the south to the Indian Sea.

The rivers in Mekran present a singular appearance during the summer months, being then almost quite dry. The following are the principal of which we have received any account: The Neam Khor, or salt river, which falls into the sea at Tiz. The Cajoo river, which rises in the hills at Suroo, and joins the ocean thirty miles west of Chobar, between *Roasim* and *Tank*. The Bunpoor river, whose course is from east to west. After its confluence with another stream which traverses the fertile plains of Lushar, it loses itself in the sands about forty miles to the westward of the town of *Bunpoor*. When visited by Captain Grant in the month of February, it was 20 yards wide and 3 feet deep.

The population of Mekran consists of many different tribes and independent chiefs, of which the Balouches are the most numerous. A corrupt Persian, mixed with Scindi, is the common language of the country. The whole force of Mekran may amount to about 25,000 men. Lead and iron are produced in the mountains to the south of Kelat. Some gold and silver have been found at Nal. Copper, tin, antimony, sulphur, saltpetre and marble are also found. See Kinnier's *Geog. Mem. of Persia*, p. 202—225.

MELANCTHON, Philip, the celebrated friend and coadjutor of Luther, was born in Bretten, a town of Saxony, on February 16, 1490. His father, George Schwartzerd, (which was the German family name,) held the office of commissary of artillery, and was distinguished by his ingenuity in the invention of military instruments, as well as by the strictness of his piety and correctness of his morals. The care of Melancthon's early studies (in consequence of his father's public engagements) was entrusted to his maternal grandfather, John Reuter, who long filled the office of mayor in Bretten. He was at first sent to a public school in his native town; but, a contagious disease having appeared among the scholars, he was soon placed under private tuition. He was instructed in the Latin language by John Hungarus, (who afterwards became a protestant preacher,) and gave early indications of his great natural capacity. He studied the Greek language with equal diligence and success at Pforzheim, under George Simlerus; and during the course of his studies in this place, had frequent opportunities of receiving the friendly advices of John Reuchlin, or Capnio, as he is more generally called, who was one of the principal restorers of learning in Germany, and who was greatly attracted by the promising talents and studious habits of young Melancthon. At the age of twelve he wrote several pieces in Latin verse, and in the following year composed a humorous comedy, which he dedicated to Capnio, from whom he received, on that occasion, the name of Melancthon, which signifies in Greek what Schwartzerd does in German, namely, "black earth." After a residence of two years at Pforzheim, he was sent to the University of Heidelberg, where he soon became distinguished by his talents, application, and amiable dispositions. He wrote most of the public harangues delivered at the university, during his attendance there; and was entrusted with the education of the two sons of Count Leonstein. The situation of Heidelberg appearing to be unfavourable to his feeble constitution of body, and his mind being chagrined by the refusal of a higher literary degree, on account of his youth, he left that university after a residence of three years, and removed to that of Tubingen, which was then celebrated for its eminent professors in every branch of literature and theology: There he devoted himself particularly to mathematics, jurisprudence, logic, medicine, and theology, and, at the age of seventeen, was created doctor in philosophy, or master of arts. He soon afterwards became a public lecturer in the university, and excited general admiration by his profound knowledge and elegant taste in the Latin classics. He was at this period the restorer of Terence, whose poetical compositions had hitherto appeared in a prosaic form; and he speedily attracted the attention of the greatest scholars of the age. He was particularly eulogized, when only a youth of eighteen, by the learned Erasmus, whose works abound in the strongest testimonies both to the eminence of Melancthon's attainments, and to the excellence of his character.

The history of his religious principles cannot be detailed with the same precision as that of his literary progress; and the principal fact, illustrative of this point, is the gift of a small Bible from his friend Capnio, upon which he was accustomed to note such explanatory hints as occurred to his own mind, or as pleased him in the works of others, and which he made his constant companion, particularly during the service of public worship. After remaining six years at Tubingen, he removed to the university of Wittemberg, where he was appointed to the Greek professorship; and where he attracted such numbers of students, that he is said to have sometimes had an audience of 1500 persons. Here he soon became the intimate friend and invaluable associate of Luther, by whom he was consulted on all occasions, and to whose great cause he rendered the most essential service by his literary resources and temperate counsels. He took a leading place in the improvement of philosophical studies, uniting the study of the Aristotelian method, with all that was valuable in the writings of the Stoics and Platonists, and thus forming a kind of eclectic system, which was named from him the Philippic method, was speedily introduced into all the Lutheran schools, by abridgements from his own pen on the various branches of philosophy. After the celebrated disputation at Leipsic between Luther and Eckius, at which Melancthon was present, he applied himself more intensely to the study of the scriptures, and the illustration of pure Christian doctrine. Having been assailed by Eckius in an abusive letter, on account of the opinions which he had expressed of the different disputants, he published a reply, drawn up with so much elegance of language, acuteness of argument, and mildness of spirit, that it proved extremely favourable to the cause of his friend. In 1520, he married a young woman of a reputable family in Wittemberg, and of a character in every respect congenial with his own. They soon became distinguished patterns of genuine piety and Christian beneficence. His house was crowded by paupers, who were never sent away empty; and his time was beset by equally numerous applicants for his advice, his recommendation, his literary aid, or merely for the pleasure of seeing so celebrated a person, to all of whom free access was granted. But, however devoted by principle and feeling to literary leisure and domestic retirement, Melancthon was frequently called by his sense of duty, to encounter that publicity, and to share in those contests, which he would otherwise gladly have shunned. During the period of Luther's seclusion in the castle of Wurtenberg, he found himself placed at the head of the reformed cause, and was fully aware of the high responsibility attached to such a situation. He discharged, at the same time, many of those clerical duties which belonged to the office of Luther; and notwithstanding all the sensibilities (we may almost say the hypochondriasm) of his nature, he often appeared in the front of the contest, which was now thickening on every side. In answer to the condemnation of the reformer's principles, published by the divines of the Sorbonne in 1521, he wrote a small but satirical pamphlet, entitled, "Adversus Furiosum Parisiensium, Theologastrorum decretum pro Luthero Apologia;" and another in the same year against Placentinus, or rather Emser, in which he details the history of the Lutheran controversy, and refutes the calumnies of the anti-reformation party. He was busy also in his university labours, exciting the youth under his care to the diligent study of Christian truth in the writings of the apostle Paul; and about the same time he produced his celebrated work, entitled, *Theological common places*, which excited great attention, and obtained an extensive circulation, not only in Germany, but also in France and Italy. It was published in Venice under the name of *Philippo de Terra Nera*, (the Italian translation of the word Melancthon); and, under this designation, was either approved, or at least uncensured; but, as soon as it was known to be the production of Philip Melancthon, it was instantly suppressed by order of the Inquisition. This work was extolled by Luther as the best book next to the Holy Scriptures, and recommended along with his own translation of the Bible, as sufficient together for the formation of a good divine. His pen was much employed in revising the translation of the New Testament by Luther; and particularly in comparing that of the Old Testament with the Septuagint version. About the middle of the year 1522, Luther having secretly got possession of a manuscript commentary by Melancthon on the Epistle of Paul to the Romans, printed it without the author's knowledge, and sent him a copy, with a very characteristic apology prefixed, of which a few sentences will not be thought unworthy of being transcribed. "Martin Luther to Philip Melancthon, grace and peace in Christ. 'Be angry and sin not. Commune with your own heart upon your bed and be still.' I am the person who dares to publish your annotations, and send you your own work. If you are not pleased with it, it may be all very well; it is sufficient that you please us. If I have done wrong, you are to blame: Why did you not publish it yourself? I threaten you farther, to steal and publish your remarks upon Genesis, the Gospels of Matthew and John, unless you supersede me by bringing them forward."

In the course of the dispute between Luther and Erasmus, the latter made several artful attempts to draw Melancthon from the cause of the reformers, by the prospect of promotion from the popish party. The reply of Luther's friend sufficiently showed that his moderation and mildness were very different from timidity or indifference: "For my part I cannot, with a safe conscience, condemn the sentiments of Luther, however I may be charged with folly or superstition—that does not weigh with me. But I would oppose them strenuously, if the scriptures were on the other side. Most certainly I shall never change my sentiments from a regard to human authority, or from the dread of disgrace." In the year 1525, he repaired to Nuremberg, on the express solicitation of the senate, to assist in planning the establishment of a public seminary in that place, and afterwards delivered an oration at the opening of the academy, but declined the offer of one of its professorships. Amidst all his public and private engagements, which he mentions in his letters as at once oppressive to his mind and injurious to his health, he found means to publish a variety of useful compositions; among which were introductions to several of the sacred books, a Latin version of the Proverbs of Solomon, and an Epitome of the Doctrines believed and taught in the Reformed Churches.

He was employed by the Elector of Saxony to draw up in the German language a memorial on the side of the reformers, to be presented to the diet, which met at Spires in 1526; and was regularly consulted by the Landgrave of Hesse on the means of promoting the reformation in his dominions. His pen was employed also in preparing a directory for the churches in Saxony, which was entitled *Libellus Visitatorius*, in which the Papists pretended to discover a difference in sentiment from Luther, because it was expressed in a strain of moderation; while Agricola, a friend of the author, and the founder of the Antinomian heresy, declaimed against its doctrine on the necessity of repentance, and involved him in a painful dispute on the subject. But he was soon called to take part in the still more serious controversy among Protestant divines on the subject of the sacrament; and, while he adhered at first to Luther's notion of consubstantiation, his opinion became gradually more inclined to that of Zuinglius. It was a more important task even than this, to which his whole faculties were required, when he was called to extend the materials furnished by Luther, and to draw up the *Augsburg Confession of Faith;* and though, in the course of the discussions on the various articles at the diet, in which he bore the principal part on the side of the reformers, he was inclined to yield more than Luther approved, in regard to the ecclesiastical jurisdiction of the bishops, (of whose good intentions he hoped too favourably,) yet, in all doctrinal points, he maintained the character of an enlightened and inflexible protestant. In these various conferences, he displayed all the excellence of his character, as well as the abilities of his mind; and all the efforts of the Romanists were exerted, without success, to gain him over to their cause. Amidst all his constitutional softness, the integrity of his principles, and the intrepidity of his mind, were repeatedly manifested; and, when Cardinal Campegius ultimately refused all toleration of the Protestant sentiments, he made this mild but resolute reply, "Well, then, we commend ourselves and our concerns to God. If he be for us, who can be against us? We shall wait with patience whatever may happen to us. If it be necessary, we would (if such be the will of God) rather fight and die, than betray so many souls." In the year 1534, he was commissioned to confer with Bucer at Casel on the sacramentarian controversy; and would most likely have conciliated matters, had Luther been disposed to moderate his violence; but, as it was, he succeeded in greatly abating the hostility of the Saxon reformer to the brethren of Switzerland. In the same year he was engaged in a similar conference with the Romanists at Leipsic, where he equally failed in his object, through the assuming obstinacy of the papists, while he equally manifested the excellence of his own spirit. His name had now attained the highest celebrity throughout the nations of Europe; and he was successively invited, or rather earnestly entreated, both by Francis I. of France, and by Henry VIII. of England, to visit their respective courts; but was prevented, in both cases, by the wishes of the Elector of Saxony, who was afraid of giving offence to Charles V and who probably augured little good from either of the monarchs. They had doubtless their own political views to gratify in the proposal; but it proves the eminence of Melancthon's name, when both these powerful princes were desirous to avail themselves of his influence. Both he and Luther had considerable hopes of inducing the king of England to pursue his apparently favourable disposition towards the cause of the reformation; and Melancthon wrote several letters, besides transmitting some of his publications to Henry, from whom he received in return, a present of 200 crowns, and the highest expressions of approbation of his zeal in the cause of the Christian religion. In consequence, however, of this communication with the English court, he formed an acquaintance with Archbishop Cranmer, to whom he had recommended Alexander Aless, a learned Scotchman, who had been driven from his native country by the violence of the Popish party, and who afterwards acquired great favour with King Henry.

Upon the appointment of a general council to meet at Mantua in May 1537, his services were again required by the Protestant leaders, to devise some common form of doctrine, which might unite the reformed churches; and to select those articles of faith, which from their radical importance, were necessary to be retained and avowed at all hazards in the proposed accommodation with the Catholics. In the prosecution of these objects, he drew up a treatise on the supremacy of the pope and jurisdiction of the bishops, which met with great approbation from the Protestant deputies; and which manifested at once his firmness in what he conceived to be essential principles, and his strong desire of a reconciliation. But many were ready to misinterpret his intention, and to censure his love of peace, while he was resisting offers from the popish princes, which perhaps few of these calumniators would have been able to withstand. In 1539, in the Protestant conference at Francfort, he was deputed to write on the subject of lawful defence; and soon afterwards addressed a letter of strong remonstrance to the wavering and wayward King of England, on his conduct in the cause of the reformation.

To give a full view of the services of this eminent and indefatigable labourer in the cause of revealed religion and of the reformed doctrines, would require us to enter into all the leading events of the age in which he lived. In a conference at Worms in 1541; in aiding the plans of the Elector of Cologne for promoting the reformation in the diocese in 1543; in rendering similar services to the Elector Palatine Frederic in 1545; in preparing for the expected council of Trent a statement of the chief reasons of the Protestant dissent in 1546; in almost every thing, in short, that was to be written—his pen was successively and unremittingly employed. After the death of Luther, with whom he consulted and corresponded on all occasions, he found himself still more unceasingly harassed by the accumulating interests of the reformation, at the most critical period of its progress. Upon the publication of the temporary rule of faith for all parties, called the Interim, (of which the emperor enforced the observance by force of arms,) Melancthon attended seven conferences at Leipsic, and wrote all the pieces which were then presented in the discussion of this imperial creed. The result of these deliberations was the publication of a treatise from his pen, and a decree of the Saxon nobility and clergy, on the observance of things of an indifferent nature. In this work, and the disputes which followed, called the Adiophoristic controversy, Melancthon has been most unjustly accused of having abandoned the truth through excessive timidity and servile compliance; but a few quotations from his published sentiments at the moment, will sufficiently expose the unfounded nature of these aspersions: "Though threatened with war and destruction, we must still adhere to the word of God, and not deny acknowledged truth. As to the danger incurred by the defence of what is preached in our churches, and we know to be truth, we will entrust the affair to God." "Let the potentates and rulers consider, amidst the alarms of war now prevalent, what they will, and what they ought to do in this affair, for the peace of the church. As for myself, I am ready, by the grace of God, to depart hence, and if need be to suffer."—"We have been lately written to, and admonished not to preach, teach, or write against this Interim; but necessity compels us to say this much, with all humility of mind, that we will not alter in what we have hitherto taught in our churches; for no creature possesses power or authority to change the word of God, and it is at every one's peril to deny or forsake the known truth. As, therefore, this Interim is opposed, in many of its articles, to the truth we have advocated, we feel it necessary to publish, in a Christian spirit, an explicit answer: the danger incurred by this measure, we cheerfully face, committing all to the eternal God, the father of our Lord Jesus Christ."

Besides arranging the order of the churches and academies in Misnia, in 1553, and assisting at a conference at Nuremburg, in 1554, for the purpose of consolidating a union between the houses of Saxony, Brandenburg, and Hesse, he was engaged in discussing the subject of the union of two natures in the Saviour, against Osiander and Stancarus, and also in vindicating himself from the clamours and calumnies excited against him by Flacius. In the expectation of being driven into banishment by the intemperate proceedings of his enemies among the more violent of the reformed, he had adopted the resolution of withdrawing to Palestine, and devoting the remainder of his life to the retirement of a hermit, and the composition of works in defence of divine truth. "At the head of all the principal literary and ecclesiastical transactions of the age," says Cox, "consulted by princes, dispatched upon every urgent occasion on different journies, summoned to private conferences and public councils, necessitated to maintain a most extensive correspondence, opposed and even insulted by a violent faction, and watched as a heretic by the partisans of the Roman hierarchy, he represents himself as tormented upon the rack of incessant engagement, and absolutely distracted with writing disputations, regulations, prefaces, and letters." Exhausted at length by his unremitting exertions, by grief for the loss of friends, and by anxiety for the fate of pure religion, he became desirous of a release from his toilsome life; and, after lingering several weeks under the influence of an intermittent fever, he expired on the 19th of April, 1560, in the sixty-third year of his age, in the full possession of his mental faculties, and in the most placid state of pious hope. Upon being asked by one of his friends, in his last moments, if he wished any thing else, he replied, "aliud nihil nisi cœlum," "*nothing else but heaven;*" and requested those who were endeavouring to adjust some parts of his clothing, "not to disturb his delightful repose." The public were allowed to gratify their anxiety to see his body before its interment; and their attachment to his character was singularly manifested, by their picking up every pen, or piece of paper upon which he had written, or any thing that he had used, however insignificant in itself. His remains were placed in a leaden coffin, and deposited close by the body of Luther. We could dwell with much complacency, and at great length, on the delineation of a character, which presents so rare a combination of intellectual and moral endowments; and which, even when it is exhibited to the world, is so seldom estimated as it merits, amidst the violence of human contentions. But it is our proper province to select and abridge the materials of biography, rather than to expand its lessons of instruction; and we must content ourselves with a very rapid sketch of what would well deserve to be placed, in all its most attractive lights, before the exasperated spirits, who crowd the departments of modern controversy.

Philip Melancthon has been invariably numbered among the most illustrious instruments of the reformation; and was by far the most powerful coadjutor, as well as the warmest personal friend of the Saxon reformer. He was peculiarly qualified to supply the deficiencies, and to correct the errors, of his intrepid associate; and it would be a difficult task to decide whether the cause of true religion was more indebted to the zealous spirit of the one, or to the persuasive virtues of the other. Nothing, at least, can be more pleasing, than to contemplate the high opinion which they entertained of each other, and the uniform steadiness of their mutual friendship amidst all the attempts of their enemies to create a disunion. "Though not perfectly *agreed*, they were perfectly *united*," says Cox, and never could be induced to regard each other as rivals. "Pomeranus is a grammarian," said Melancthon, "I am a logician, and Justus Jonas is an orator; but Luther is good at every thing, the wonder of mankind; for whatever he says or writes, it penetrates the heart, and makes a lasting impression." "I am born to be a rough controversialist," said Luther, "I clear the ground, pull up weeds, fill up ditches, and smooth the roads. But to build, to plant, to sow, to water, to adorn the country, belongs to Melancthon."

Melancthon's early talents, extensive learning, and classical acquirements, have been already noticed; but his intellectual acuteness in discriminating between truth and sophistry, was not less distinguished than the elegant perspicuity with which he conveyed his sentiments. He possessed an extraordinary memory, which was greatly aided by the regularity of his habits, and the equanimity of his mind; and was not less remarkable for the facility with which he could recollect his well arranged stores of information. He spared no time or application in the investigation of every important topic; and, in all his researches or discussions, was actuated by the most undeviating love of truth. His own intentions were as upright as his conceptions were clear; and there was a kind of *transparency* (as has been well expressed) in the whole stream both of his arguments and his motives. "I will give you an answer to-morrow," he said on one occasion to Eckius, who had made use of some puzzling sophism in their disputation. "There is no merit or honour in that," said his antagonist, "if you cannot answer me immediately." "Mi doctor," replied Melancthon, with the greatest composure, "non quæro meam gloriam hoc in negotio, sed veritatem: cras, volente Deo, me audies." It was his avowed principle to speak what he thought firmly, but modestly; and to concede what he deemed might be conceded with unambiguous ingenuousness. This was not a spirit likely to please any party in an age of violent contention; and he was incessantly assailed and tormented, through the whole of his life, by the bigotry both of friends and enemies. Yet his dispassionate temper, unbiassed candour, and love of peace, were by no means (as has been often advanced) the consequence of scepticism in principle, insensibility of feeling, or timidity of spirit. The most fiery zealot in the cause of the Reformation never pursued its interests with greater perseverance than he did; nor did he even temporize in those points, which his penetrating mind saw to be essential; and he would have died (as he often avowed) for what he maintained. He possessed also all that acute and excitable feeling, which generally accompanies true genius; and his anxiety for the success of the great cause which he had embraced with all the ardour of enlightened piety, arose often to the degree of absolute hypochondriasm.

His acquisitions of knowledge were made with little exertion; and his unclouded serenity of mind kept his faculties always fit for service. His bodily frame was slender, and his constitution never robust; but his habits were regular, and his mode of living strictly temperate. He retired to rest at an early hour, and usually rose a little after midnight. He estimated time as the most precious of all possessions; and, when he made any appointment, expected it to be kept literally to a minute. His services to general literature were of the highest order, and he had great influence in reviving the study of the ancient writers. He led the way in classical composition among his countrymen; and, though his attempts at versification were far from being successful, he wrote Latin in prose with an ease and purity rarely equalled. Amidst all the avocations in which he was involved, he employed the greater part of every year in giving lectures to 1500 pupils; and, even among the increased infirmities of his last days, he persevered in the labours of his class with an assiduity almost approaching to obstinacy.

But neither his attachment to literature, nor his multifarious engagements in public affairs, could seduce him from the participation of domestic feelings and duties. His attention to his own family was never relaxed amidst his greatest perplexities, and he was occasionally found by his visitors holding a book in one hand, and rocking his child's cradle with the other. He was fond of the society of children in general, to whom he could render himself at once a captivating and instructive companion, joining cheerfully in their sports, and exercising his ingenuity in devising amusements suited to their years. He was much inclined at all times to a jocular strain of conversation; and was so extremely frank in his communications, from the entire purity of his motives, as frequently to expose himself to the artifices of designing men. He was a pattern of sympathy towards his friends; and was distinguished at all times by the most disinterested generosity of disposition, which he often carried to a faulty extreme. The various presents of gold and silver coins, or other curiosities which he frequently received, he would often give away to the first person who might be induced to ask for them; and it is said, that, on one occasion, having offered a stranger any particular article in a large collection which he was showing to him, and the visitant having, with consummate cupidity, expressed a wish for them all, he actually granted the unreasonable request, while he could not conceal his displeasure at such an instance of avaricious effrontery. He was equally profuse in his daily charities; and so completely disinterested, as to decline repeatedly proposed additions to his salary in the university, as well as to refuse the most lucrative offers of promotion, and proffered presents from his princely friends. He was remarkably humble in his whole deportment; and was often known to perform various menial offices for himself. He was invariably animated by a gentle and peaceful spirit, averse from disputation, almost never known to be irritated in the course of debate, and still less to have harboured resentment in consequence of any heat that might have been excited, or hasty expression thrown out. Nor was he, by any means, a tame and feminine character; but, while "he was apt to sink into a kind of yielding softness under the influence of mild and generous treatment, (to use the words of Mosheim,) if his adversaries so far forgot themselves, as to make use of imperious language and menacing terms, then a spirit of intrepidity, wisdom, and independence, animated all his words and actions, and he looked down with contempt on the threats of power, the frowns of fortune, and the fear of death." But his passions were all controlled by the dictates of reason, and especially by the power of fervent yet unobtrusive piety, which was the brightest ornament of his exalted character, and the leading motive of his valuable exertions. The most ample and most correct edition of his works, is that which was published by his son-in-law, Caspar Peucer, at Wittemberg, in 1601, in four volumes folio. See Mosheim's *Eccles. Hist.* vol. iv. ; Melchior Adam *Vitæ Germ. Theologorum* ; Seckendorf *Hist. Lutheranismi* ; Bayle's *Critical Dictionary* ; Camerarii *Vita Melancthonis* ; Cox's *Life of Melancthon* ; Milner's *Church History*, vol. iv. and v. (*q*.)

MELCOMBE-REGIS. See Weymouth.

MELKSHAM, a village of England, in the county of Wilts, consists chiefly of one long street, of which the houses are built of a soft free-stone. It contains a parish church, and three meeting-houses for Quakers, Independents, and Baptists. It carries on the manufactures of broad cloths. Number of houses 785. Population 4030.

MELLITIC Acid. See Chemistry.

MELODY, in Music, such a pleasing *succession* of musical sounds, as was by the earliest writers on music called Harmony, (see that article,) a term which now is exclusively applied to denote the pleasing effects of a proper selection of sounds *heard together* at the same time. In correct performances by a choir of good voices, or by a band of Perfect *Instruments*, making *Perfect* Harmony, (see these articles,) such as violins, violoncellos, &c. or a Listonian or Enharmonic *Organ*, are capable of producing, when skilfully played, a considerable number of the leaps or steps of the melody in such performances are necessarily tempered, or made a small quantity larger or smaller, than that exact quantity which each of such steps or intervals must have when introduced in harmony ; that is, when the limiting sounds of such intervals are heard together at the same instant. A nice and well practised ear for music, will doubtless perceive *the temperament of the melody* of which we are speaking, and can hardly fail, on first hearing and considering them, during an enharmonic performance, to consider them as defects, and wish for their being avoided. Every attempt, however, to do so, by removing the temperaments from the melody to the harmony, is accompanied by so much interruption and debasement from *the beats*, by which such tempered harmonies are accompanied, as to produce conviction that the harmony ought, in all instances, to be kept perfect ; and the temperaments, by which unavoidably all music in parts is attended, must be thrown entirely into the leaps of the melody, where no beats or beatings will be found to accompany their use. See this subject further discussed in the *Philosophical Magazine*, vol. xxvii. p. 314. (*e*)

MELOS. See Milo.

MELROSE, a town and parish in the county of Roxburgh, extending in length from north to south about seven miles and in breadth from five to seven miles. The population is about 2446.

The soil of this parish is various. Towards the south, it is for the most part a strong clay, excellently adapted for wheat. The banks of the Tweed, which winds through the parish, consist of a fine light dry soil, fit for all kinds of grain. On the north side of the river, the soil is of three kinds: 1st, A light earth, mixed with sand, upon a gravelly bottom ; 2d, A strong clay upon a till, full of springs, and very wet; and 3d, Moss. The northern part of the parish is hilly, and makes excellent sheep pasture, interspersed with a few small fields under cultivation. The valued rent of the parish is 19,985*l*. 4*s*. 6*d*. Scots.

The town of Melrose, which gives its name to this parish, was formerly a burgh of regality. It is pleasantly situated at the bottom of the Eildon hills, on the north side, and on the edge of a fertile valley, upwards of a mile in length, intersected by the Tweed, which runs through it in a serpentine direction, and surrounded by hills of a considerable height. In this valley, besides Melrose, are the villages of Danieltoun, Darnick, Bridge-end, Gattonside, Newstead, Eildon, Newtown, and Blainslie.

Melrose was long celebrated for its manufacture of linens ; but for several years past this trade has been very much upon the decline. The business of bleaching linens is carried on to a considerable extent; and the woollen manufacture has, of late, been cultivated with success.

A little to the south of Melrose, are the three Eildon hills. The base of them may be in compass six or seven miles ; the heighth of two of them to the north about a mile and a half. On the top of the north-east hill are plain vestiges of a Roman camp, well fortified with two fosses and mounds of earth more than a mile and a half in circuit, with a large plain near the top of the hill, on which may be seen the *prætorium*, or the general's quarter, surrounded with many huts. The situation seems to have been skilfully selected, and it has all the properties of a well chosen camp, according to the rules of Vegetius. There is a large prospect from it of all the country ; it has many springs of good water near it ; the sides of the hill have been covered with wood ; and the camp is so extensive, that neither man, beast, nor baggage, could be straitened for room. On the north side of the middle hill, there seems to have been a second camp, from which there is a large ditch for two miles to the west, reaching to another camp on the top of Caldshielhill. This camp has been strongly fortified with a double trench, and the circumvallation of it continued for a considerable way ; and, along with the camp called Castlestead, it forms almost a triangle with the large camp in Eildon hills. The vestiges of two other large camps are also found in this neighbourhood ; the one on the head of the hill, on the side of which the village of Gattonside is founded, north of the Tweed, which is surrounded by a wall of stone about half a mile in compass ; the other about half a mile to the east, on the top of the hill opposite to Newstead, which seems to have been about three quarters of a mile in circumference, and is called the *Chester Know*, or *Knoll*. The eastern Roman military road is visible in many quarters of this country, raised in some places considerably above the adjoining fields, and of a considerable breadth, with military stations on some parts of it.

But the most remarkable monument of antiquity to be found in this quarter, is the abbey of Melrose. Various religious foundations, of different dates, appear to have existed at this place. The ancient monastery of Old Melrose, situated on a little peninsula formed by the windings of the Tweed, was probably founded about the end of the sixth century. The venerable Bede, who was born in 673, gives an account of its situation on the bank of the Tweed, and also of its abbots. It was a famous nursery for learned and religious men, and probably continued until the other one, at the present Melrose, was founded by King David. The convent of Old Melrose was enclosed with a stone wall, reaching from the south corner to the west corner of the Tweed, where the neck of land is narrow; and the foundation of the wall is still to be seen.

About a mile to the west of this, on the Tweed, stands the village of Newstead, a place remarkable for another abbey on the east side of it, called Red Abbey-stead; and about half a mile from Newstead, on the south side of the river, stands the present abbey of Melrose. This monastery, from the ruins which yet exist, appears to have been truly magnificent and spacious. It still continues to be the admiration of strangers; and from the height and embellishment of its columns, the symmetry of its parts, the beauty of the stone of which it is built, and the delicacy of its sculpture, it may be regarded as one of the finest specimens of Gothic architecture which exist in this country. It was founded by king David in 1136, dedicated to the Virgin Mary, and endowed with large revenues and many immunities, as appears by the charters granted to the abbot and convent by our kings. The monks were Cistertian, and the monastery of Melrose was a mother church or nursery for all that order, in many various and remote regions of Scotland.

The church is built in the form of St. John's cross. The chancel, which is a very stately fabric, is still standing; its roof is very curious, and has much of the scripture history sculptured upon it. Much of the western part of this building is so entirely demolished, that it cannot be precisely ascertained how far it reached in that direction. What still exists is of the following dimensions. Its length is 258 feet, breadth 137½, circumference about 943; height of the east window 24, breadth 16; height of the south window 34½, breadth 15½; height of the steeple 75, the spire gone. The east window, at which was the great altar, is a beautiful structure, consisting of four pillars or bars, with a great deal of curious work between them; and on each side a great number of niches for statues; on the top, an old man with a globe in his left hand, resting on his knee, and a young man on his right, both in a sitting posture, with an open crown over their heads. (See Plate CLXX. of Civil Architecture.) On the north and south of this window are two others of smaller dimensions. The niches are curiously carved, both the pedestals and canopies, on which several figures of men and animals are curiously cut. On the south-east of this church are a great many musicians, admirably cut, with much pleasantness and gaiety in their countenances, accompanied with their various instruments; also nuns with their veils, some of them richly dressed. The south window is very much admired for its height and curious workmanship. There are niches on each side and above it, where have been statues of our Saviour and the apostles. Besides, there are many other figures on the east, or on the west side of this window: monks curiously cut, with their beards, cowls, and beads; a cripple on the back of a blind man; several animals cut very nicely, as boars, greyhounds, lions, monkeys, and others. There are about sixty-eight niches in the whole, standing; the statues were only demolished about the year 1649.

With regard to the inside of the church, on the north side of the cross, there are beautiful pillars, the sculpture as fresh as if it had been newly cut. On the west side is a statue of St. Peter; and to the south of it one of St. Paul. In the middle of the cross stood the steeple, a piece of noble architecture; a quarter of it yet standing, but the spire gone. The roof of the south side of the cross is still standing, where there is a beautiful stair-case, much admired, the roof of it winding like a snail-cap. There was within the church a vast number of fonts, curiously carved, and altars dedicated to various saints. In the portion of the church where worship is at present performed, there are two rows of pillars of excellent workmanship, especially that to the south-east, which, for fineness, looks like Flanders lace.

With regard, lastly, to what was in part or altogether separated from the body of the church, there was a cloister on the north side, a part of the walls of which are still remaining; and where may be observed pleasant walks and seats, with a great many fine flowers of various kinds, nicely cut. The door at the north entry of the church is curiously embossed; and the foliage here, and in several places of the church, very beautiful. There were also here a great many fine buildings within the convent, for the use of the abbot and monks, with gardens and other conveniences; all inclosed within an high wall, about a mile in circuit. Besides the high church, there has been a large fine chapel where the manse now stands; and another house adjoining to it, where the foundation of the pillars is still to be seen. On the north side of this house, there has been a curious oratory, or private chapel, the foundation of which has been lately discovered, and a large cistern of one stone, with a leaden pipe, conveying the water to it. See *The Statist. Account of Scotland*, vol. ix.; Forsyth's *Beauties of Scotland*, vol. ii.; and the *Description of the Parish of Melrose*, by the Rev. Mr. Milne, 1743. (z)

MELTON MOUBRAY, a market town of England, in Leicestershire, is situated in a vale on the banks of the river Eye, over which there are two good bridges. The Oakham canal, which is also crossed by a good bridge, runs behind the principal street. The town consists of four streets, in the form of a cross, and has many well-built houses. The church, which is very large, consists of a nave, aisles, transept, and chancel, with a high and elegant tower in the centre. There is here a free-school for girls, and three annual fairs. The population of the parish in 1811 was 411 inhabited houses, and 2141 inhabitants.

MELVILLE, Andrew, a learned Scotsman, and one of the most distinguished successors of John Knox in the Prysbyterian church, was the youngest of nine sons of Richard Melville of Baldovy, in Forfarshire, and was born on the 1st of August, 1545. In his second year, he lost his father at the battle of Pinkie, and was brought up in the family of his eldest brother Richard, where he was treated with great tenderness and affection. While a child, he was distinguished as much for the quickness of his capacity, as for the delicacy of his constitution; and his brother resolved to give him as complete an education as the age could afford. He was instructed in grammar by Thomas Anderson, then schoolmaster, and afterwards minister, at Montrose, who also initiated him into the principles of the reformation; and after having completed the usual routine of elementary education at the Latin school, he studied the Greek and French languages under Pierre de Marsilliers, a Frenchman, who was then engaged in teaching at Montrose. In 1559, he became a student in St. Mary's College, St. Andrews; and after completing his academical course there, he sailed to France in his nineteenth year, and engaged ardently in the study of letters and philosophy in the university of Paris. For the purpose of studying the civil law, he repaired to Poitiers in his twenty-first year; and, on his arrival, he was made a regent in the college of St. Marceon. Here he continued three years, prosecuting with great success the study of jurisprudence, and at the same time distinguishing himself as a teacher of rhetoric. His next object was to study theology, and with this intention he went to Geneva, where he immediately proved himself worthy to fill the vacant chair of humanity.

In the year 1574, at the urgent desire of his friends in Scotland, Melville resigned his office at Geneva, and returned to his native country. Some of his friends now endeavoured to persuade him to accept the appointment of domestic instructor to the Regent Morton; but this he declined, and spent a few months in his elder brother's house, assisting the studies of his nephew, James Melville, who had recently completed the usual course of academical education at St. Andrew's. Soon afterwards, at the solicitation of Archbishop Boyd, and other leading men in the west, he accepted the office of Principal of Glasgow college, and carried his nephew James along with him to act as regent. In this situation he laboured with great diligence and success, introduced a new plan of study, and made many useful improvements in the mode of teaching; and a new foundation, which was given to the college at this time by royal charter, ratified all the dispositions which Melville had made for the advancement of learning. Among his other services to the university, he deserves the credit of having founded the public library, though it does not appear that he enriched it with any donations from his own collection. About this time, he first became known as an author, by the appearance of his poetical translation of the Song of Moses, &c. printed at Basil, in 1574,—a collection which experienced a most flattering reception from all the men of learning and taste in Europe.

The constitution of his office, as a professor of divinity, entitled him to a seat in the ecclesiastical judicatories; and he took a very active interest in the public affairs of the church. When he arrived in Scotland, an incongruous species of church government,—nominally Episcopalian, but which neither satisfied Episcopalians nor Presbyterians,—had been introduced; but Melville was convinced that prelacy is not founded on the authority of Scripture, or on the practice of apostolical times; and having conceived a partiality for Presbyterian parity, in consequence of his experience of its good effects in Geneva, he determined to exert himself to establish the same model in his own country. In the month of March, 1575, he was first a member of the General Assembly; and his name was included in a committee appointed to confer with the government on the subject of the polity of the church, and to prepare a scheme of ecclesiastical administration, to be submitted to a future Assembly. In the year 1578, the second book of Discipline was approved by a General Assembly, in which Melville presided; and from that period it has been the standard of Presbyterian church government.

But the General Assembly, in their zeal to reform the government of the church, were not inattentive to the means of improving the seminaries of education. At the suggestion of Melville, in conjunction with Arbuthnot and Smeton, plans were formed for amending the constitutions of the universities of St Andrew's, Glasgow, and Aberdeen, on a principle similar to that which had been recommended by the reformers in the first book of Discipline. A favourite project with Melville was, to transform one of the three colleges of St. Andrew's into a school of divinity; and, through his influence with the government and the church, the design was accomplished in the year 1579. Melville himself was placed at the head of the new theological seminary, by the voice of his country; and for more than twenty years the success of the institution exceeded the most sanguine expectations.

Melville began to discharge the duties of principal and professor of divinity in the new college of St. Andrew's, in December, 1580, with the assistance of his nephew James, as professor of the oriental languages, and John Robertson, as professor of the New Testament. His class was crowded with auditors, consisting not only of students of theology, but of masters in the other colleges; all of whom acknowledged the singular ability with which he accomplished his arduous undertaking. Melville, however, with all his excellencies, appears to have been passionately fond of innovation; and to a rational discernment of the defects of the Aristotelian philosophy, he added an undue admiration of the writings of Ramus, whose lectures he had attended in his youth, and whose spirit he had freely imbibed. The Peripatetic prejudices of the professors in St. Salvator's and St. Leonard's college were roused to fury by the attacks upon their favourite author; and, for some time, their indignation could scarcely be appeased. Yet such was the address and superior intelligence of the principal, that he not only disarmed their animosity, but speedily converted the most obstinate among them to his own peculiar views.

In addition to his academical charge at St. Andrew's, Melville, during the first two or three years of his residence, generally performed divine service, and took a share of the other ministerial duties of the parish. His gratuitous labours were highly gratifying to the inhabitants in general; but the freedom and fidelity with which he reproved vice, exposed him to the resentment of several leading individuals; and the most atrocious calumnies against Melville were conveyed to the king, whose mind was predisposed to receive any insinuation to his disadvantage. He was accordingly summoned to appear before the privy council on a charge of treasonable expressions uttered in one of his sermons; and though he produced the most explicit proofs of his innocence, he was sentenced to imprisonment in the castle of Blackness, for having declined the jurisdiction of the council, and for having conducted himself proudly and contemptuously in their presence. Melville, however, contrived to make his escape to England; whence he returned twenty months afterwards, in company with the banished noblemen, who had been denounced as traitors on account of the affair of Ruthven, and who appeared before the gates of Stirling castle with such a numerous force, that the king was glad to re-admit to his councils the men, who, only two years before, had fled from his vengeance.

After being reinstated in his office at St. Andrew's, Melville and his nephew took an active part in the proceedings of the synod of Fife, which terminated in the excommunication of Archbishop Adamson, for having dictated and defended the laws subversive of ecclesiastical discipline. When Adamson was relaxed from censure, and restored to his see, Melville was charged to retire to the north of the Tay, and was not permitted to return to his post, till the college had reluctantly consented to oblige one of the king's menial servants, by renewing a lease, to the great diminution of the rental. Not long afterwards, the king, accompanied by Du Bartas the poet, on a visit to St. Andrew's, had an opportunity of hearing from Melville a most spirited and learned, though extemporaneous refutation of an elaborate lecture by Adamson, in favour of his views of royal prerogative.

In the year 1588, Melville, who had been moderator of the preceding General Assembly, summoned an extraordinary meeting, to concert measures for averting the dangers apprehended from the Spanish armada; and, at his suggestion, a deputation of the ministers, barons and burgesses, waited on his Majesty with the result of their deliberations, proffering their lives and their fortunes in defence of the religion and government of the kingdom. The king was offended with the officious loyalty of his faithful subjects, but was pleased to appoint a committee of the privy council to co-operate with them, in devising means for frustrating the designs of the enemy.

On occasion of the queen's coronation, Melville, who was invited as one of the guests only two days before, pronounced a Latin poem, which was received with so much applause, that the king publicly declared that he and the country had that day received such honour as could never be requited. This poem, entitled *Stephanis Kion*, was printed next day, and was received with the highest expressions of admiration by the first scholars of the age. Lipsius exclaimed, *Revera Andreas Melvinus est serio doctus;* and Scaliger, with far more liberal praise than he was accustomed to render, was not ashamed to say, *nos talia non possumus.*

Soon after the death of Archbishop Adamson, in 1592, an act of parliament was passed, ratifying the government of the church by general assemblies, provincial synods, presbyteries, and kirk sessions, and explaining away, or rescinding the most offensive of the acts of the year 1584. This important statute is considered to this day as the legal foundation of the Presbyterian government; and it was regarded by Melville as an ample reward for his laborious efforts.

A tumult which took place at Edinburgh on the 17th of December, 1596, was seized by the court as a handle for the purpose of effecting a change in the constitution of the church; and Melville's influence with the synod of Fife, and with the leading ministers, was most strenuously exerted to counteract the projected measures. A General Assembly was summoned by the king to meet at Leith; and as it was composed chiefly of ministers from the north, who were studiously infected with prejudices against their southern brethren, the adherents of Melville were left in the minority. The next Assembly at Dundee was not quite so tractable, owing to the presence of Melville. To annihilate, or at least to depress this ascendancy, the king proceeded in person, accompanied by his council, to St. Andrew's, to hold a royal visitation of the university; and there, after searching in vain for matter of accusation against Melville, it was ordained that all professors of theology or philosophy, not being actual pastors, should thenceforth be precluded from sitting in sessions, presbyteries, synods, or assemblies, and from teaching in congregations. Preparation was now made for restoring the order of bishops, and the first approach to this measure, was to induce the commissioners of the General Assembly to solicit that the ministers and elders of the church might be represented in parliament. A statute was accordingly passed, declaring prelacy to be the third estate, and asserting the right of such ministers as should be advanced to the episcopal dignity to the same legislative privileges which had been enjoyed by the former prelates. When the Assembly met at Dundee, the king did not venture to introduce the business, till he had commanded Melville and his colleague Johnstone to retire from the town; and the measure was at last carried by a majority of ten. In a conference at Falkland, Melville, in presence of his majesty, maintained his sentiments with his accustomed fearlessness and vehemence, and the king judged it prudent to refer all the matters which were still intended to be adjusted to an assembly which met at Montrose in March, 1600. Melville appeared as a commissioner from his presbytery, and, though not suffered to take his seat, his counsels and his unconquerable zeal served to animate and confirm the resolution of his brethren; and the assembly was with great difficulty prevailed upon to adopt the scheme of the court, under certain modifications.

Melville was a member of the assembly at Burntisland in May 1601, when the king thought fit to renew his engagements as a covenanter, and made a speech to shew the necessity of revising the translation of the Scriptures. In the course of the following year, his Majesty issued a *lettre de cachet*, charging Melville to confine himself within the walls of the college, because he had used some strong expressions in a discourse at the weekly exercise, condemning the worldly and unfaithful spirit prevalent among the ministers. The purpose of this severity was frustrated by the resolution of the presbytery, to transfer the exercise of the New College, and to employ the Latin tongue as the vehicle of their sentiments. At the accession of James to the throne of England, Melville, who had now obtained the indulgence of going six miles round St. Andrews, wrote three congratulatory poems, which prove at least that harsh usage had not the power of restraining the excursions of his fancy.

In the progress of James to the metropolis of England, the Puritans, who were universally favourable to his title, presented a petition, representing their grievances, and praying that the corruptions of the church might be removed. The two universities publicly declared their dissatisfaction with this petition, and denounced vengeance against every one who should presume to question any part of the doctrine or discipline of their church. The terms of these declarations were peculiarly offensive to Melville, and provoked from his powerful pen a most caustic satirical poem, well known by the abbreviated title, *Anti-Tami-Cami-Categoria.* Many attempts were made to retort upon the author; but none of them wounded so deeply, or attracted so much notice, as the original poem.

In 1604 and 1605, the activity of Melville and his nephew, in maintaining the rights of the General Assembly, was so displeasing to the sovereign, that a warrant for their imprisonment was sent from London; but the council found reasons for declining to execute it. In 1606, Melville waited on the parliament at Perth, on behalf of his presbytery, and protested against the act restoring Episcopacy in its ancient form, and reviving chapters; but he was never more suffered to make a similar appearance. He received a letter from the king, ordering him to repair to London before the 15th of September, along with seven other eminent ministers, most of them from Fife, to treat of the affairs of the church. Here they maintained an animated controversy in presence of his majesty, attended by a numerous assemblage of the English and Scottish nobility, and other officers of state, as well as dignitaries of the church. On Michaelmas day, they were ordered to attend the royal chapel, which was decorated with great magnificence. Melville, conceiving that the service did not differ materially from that of the church of Rome, imprudently wrote an epigram expressive of his idea, and as an incorrect copy of it was conveyed to the king, the author was summoned to appear before the English privy council; and the proceedings terminated in his being found guilty of *scandalum magnatum*, and committed to the Tower. His office was declared vacant, and one Robert Howdie was appointed his successor.

The first year of his imprisonment was aggravated by wanton severity, and particularly by that refinement of cruelty, which attempted to shackle the faculties of his mind, by depriving him of the means of expressing his thoughts either by writing or oral communication. Through the influence of Sir James Sempill, he was removed, at the end of ten months, to a more healthy and spacious apartment, and was allowed the use of pen, ink, and paper. When the rigour of his confinement was relaxed, he was consulted both by Arminius and his antagonist Lubbertus on their theological disputes. He still continued to refresh his mind by occasional poems; and in two or three letters to his nephew, he reviewed Dr. Downham's sermon on Episcopacy. In 1610, he printed a specimen of poetical translations of the Psalms into Latin verse; and he never wrote a letter to his nephew, without transmitting copies of some of his verses.

After four years imprisonment, Melville, on the intercession of the Duke of Bouillon, was permitted to accept the office of professor of divinity at the Protestant university of Sedan, in France; but the infirmities incident to the age of three score and ten were now gathering round his head, although he continued to write and act with all the force and fire of his youth. In his 74th year, he wrote an epithalamium on the marriage of the Duc de la Tremouille to the daughter of his benefactor Du Bouillon; and he wrote and published, a year or two afterwards, a treatise in opposition to the Articles of Perth. His health, however, which had been broken by his long confinement, was now sadly wasted; and he died in the year 1622, at the age of seventy seven.

Melville possessed strong natural talents, and his mind was enriched with the choicest stores of ancient and modern learning. His ascendancy was owing entirely to his genius and erudition, and not to any of the arts of management and intrigue. His piety was fervent and unaffected; his benevolence enlarged, but unobtrusive; he was ardent in his pursuits, and disinterestedly zealous in the public service. He possessed great independence of spirit, an unyielding boldness in word and action, and amazing readiness and rapidity in debate. In short, his talents, his erudition, and his heroic courage, well qualified him for a Presbyterian leader in the difficult times in which he lived. See Dr. M'Crie's *Life of Andrew Melville*, &c. Edinburgh, 1819. (z)

MEMEL, a town of Eastern Prussia, is traversed by the small river Dange, which enters the Kurische-Haff, and which, being here about 11 feet deep, allows small boats to pass directly to the sea. The town consists of two parts, Alstadt, the old town, and Frederickstadt; and it has also three suburbs, one of which is beyond the Dange. The town is well fortified, and has a German, Lithuanian, and a Calvinist church. Although the harbour of Memel is large, yet it is obstructed by quicksands, which prevent vessels that draw more that 18 feet of water from entering it. The trade of Memel, which is nearly the same as that of Koningsburg, Elbing, and Dantzic, consists of square timber, round timber, oak and fir staves, linseed, skins, hemp and flax, tallow, bristles, wax, feathers, and Lithuanian yarn. Its imports are chiefly articles of colonial produce. The average number of vessels which trade to this port is between 600 and 700, above two-thirds of which are British. In 1800, 574 vessels arrived, and 584 cleared out; of which 353 were British, 128 Russian, 38 Danish, and 26 Swedish. In 1815, 441 vessels arrived, and 429 cleared out. In 1816, 460 vessels arrived, and 439 cleared out. In 1801, there were here 20 great commercial houses. There is held annually at Memel a fair, frequented by the inhabitants of Courland and the Jews of Poland, where nearly 450,000 crowns worth of merchandize are sold. Population about 6000. East Longitude 21° 50′ 20″ and North Lat. 55° 42′ 15″. See Catteau's *Tableau de la Mer Baltique*, vol. ii. p. 304; and Rorsdanz's *European Commerce*, p. 118.

MEMORY. See MNEMONICS.

MEMPHIS is the name of an ancient city of Egypt, which was both large and populous, and celebrated for its magnificent temples and palaces. Dr. Shaw is of opinion that Giseh or Djiza now occupies the scite of Memphis; but there is reason to think, from the testimony of Strabo, Pliny, &c. that it was situated at some distance from Giseh. Savary places it at Menf or Memph, but Dr. Clarke, who agrees with him in his locality of Memphis, says that the name of the village is *Menshee a Dashoo*, which seems to be Pococke's *El Menshieh Dashour*. See *Herodotus*, Lib. ii. Pococke's *Description of the East*, vol. i. p. 49. Savary's *Letters on Egypt*. Hamilton's *Egyptiaca*, chap. xi. and Clarke's *Travels*, vol. iii. p. 128 and 158.

MENELAUS. See GREECE and LACEDEMON.

MENGS, ANTHONY RAPHAEL, a celebrated painter, was born at Ausig in Bohemia, on the 12th of March, 1728. At the age of 12 his father, who was a miniature painter, carried him to Rome, where he remained three years, studying and copying the works of celebrated painters. Upon his return to Dresden, he employed himself in painting portraits in crayons, in consequence of which be became known to the king of Poland, who made him his cabinet painter, and gave him a house and a pension. Mengs now returned to Rome to resume his early studies, and he began to compose his own pictures. Here he married a lady, Margarita

Guazzi, with whom he hoped to establish himself permanently at Rome; but at the end of four years his father forced him to return to Dresden in 1749, and having seized his whole property, turned him from his house. The king of Poland, with the greatest liberality, gave him a house and carriage, doubled his pension, and permitted him again to visit Rome.

Here he copied the School of Athens by Raphael, for the Earl of Northumberland; and, in consequence of the stoppage of his pension, he executed a fresco-ceiling in the church of the Augustines, which obtained him great celebrity.

The king of Naples, who had admired some of Mengs's pictures, sent for him to Madrid when he ascended the Spanish throne, and offered him a salary of 2000 dollars, a house and a carriage. Mengs accepted this splendid offer, and arrived in Spain in October, 1761, where he was received with great kindness.

Having fallen into a decline, he obtained permission to return to Rome for the benefit of his health. Here he regained his usual strength, and was employed by Clement XIV. to paint in the Vatican. The king of Spain, however, commanded him to repair to Madrid; but he had scarcely continued in Spain more than two and a half years when his ill-health returned. The king gave him full liberty to return to Rome, with his pension of 3000 scudi, and 1000 more to divide among his daughters.

After he had been some time in Rome, he had the misfortune to lose his wife; and his old complaint having again attacked him, he died in 1779, in the 58th year of his age.

His writings were published after his death by his friend the Chevalier Azara, who states that all the technical part of Winkelman's *History of the Arts* was written by Mengs.

MENSURATION.

Geometrical magnitudes of every kind may be expressed in numbers, by considering how often each contains some unit of its own kind.

A square, the side of which is the lineal unit, serves to measure surfaces; and the number of times a superficies contains its unit, is its *area*.

A cube, of which the base is the superficial unit, or its side the lineal unit, is the unit of solids; and the number of times it is contained in a solid is the *content*, or *solidity*.

Mensuration is the system of rules by which the numeral measures of geometrical magnitudes are found: It may therefore comprehend Plane Trigonometry, although, for reasons of convenience, we propose to treat that subject as a distinct theory.

The smallest lineal unit in common use is an inch, and from this other measures are formed, as in the following Table.

TABLE OF LINEAL MEASURES.

12	Inches	=	1 Foot.
3	Feet	=	1 Yard.
2	Yards	=	1 Fathom.
5½	Yards	=	1 Pole *or* Rod.
40	Poles	=	1 Furlong.
8	Furlongs	=	1 Mile.
3	Miles	=	1 League.
60	Geographical Miles	=	1 Degree.
or 69⅓	English Miles .		

Note.—An inch is supposed equal to 3 barley corns.

4 Poles *or* 66 Feet 100 Links, each 7.92 inches	=	1 English Chain.
100 Links, measuring 74 feet	=	1 Scots Chain.

The measures of France may be converted into those of England, by considering that a French toise = 2.1315 English yards; and a French metre = 39.371 English inches.

TABLE OF SUPERFICIAL MEASURE.

144	Square Inches	=	1 Square Foot.
9	Square Feet	=	1 Square Yard.
30¼	Square Yards	=	1 Square Pole.
40	Square Poles	=	1 Rood.
4	Roods	=	1 Acre.
10	Square Chains *or* 100,000 Square links	=	1 Acre.
640	Acres	=	1 Square Mile.

Note.—The Scots acre is to the English acre as 100.000 to 78,694, or, in smaller numbers, 48 Scots acres = 61 English acres.

TABLE OF SOLID MEASURE.

1728 Cubic Inches	=	1 Cubic Foot.
27 Cubic Feet	=	1 Cubic Yard.

Note.—282	Cubic Inches	=	1 Ale Gallon.
231	do.	=	1 Wine Gallon.
2150.42	do.	=	A Winchester Bushel
105	do.	=	1 Scots Pint.

The Wheat Firlot contains 21¼ Scots Pints.
The Barley Firlot contains 31 Scots Pints.

SECTION I.

MENSURATION OF PLANE FIGURES.

Rectilineal plane figures may be resolved into triangles; therefore the mensuration of their sides and angles may be referred to Plane Trigonometry. The determination of their areas forms the subject of this section.

Problem.

To find the area of a parallelogram.

Case I. When the base and perpendicular are given.

Rule. *Multiply the base by the perpendicular height, the product will be the area.*

Let AB and AD. (Plate CCCLXXII. Fig. 1.) the sides of a rectangle ABCD, be divided into parts, each equal to the lineal unit by which they are measured, and let lines be drawn through the points of division parallel to the sides: These will divide the figure into equal squares, each equal to the superficial unit. And since there will be as many squares in a row in the direction of either side as there are units in that side, and as many rows as there are units in the other side, the whole number of squares, or the area, will be the product of the numbers which express the lineal measures of the sides. For example, if the lineal unit be contained four times in one side, and three times in the other side, the area of the rectangle will be $4 \times 3 = 12$; that is, it will contain the superficial unit 12 times.

Since every parallelogram is equal to a rectangle having the same base and altitude, (See Geometry, Sect. IV. Prop 1.) its area will be the product of the base by the perpendicular height.

Example 1. A rectangular board is 5 feet 6 inches long and 9 inches broad, what is its area?

Here the base is 5 *f.* 6 *in.* = 66 *in.*, and the perpendicular height 9 *in.*: The area = 66 × 9 = 594 *sq. in.* = 4 *sq. f.* 18 *sq. in.* = $4\frac{1}{8}$ *sq. f.* Or, by vulgar fractions, since 5 *f* 6 *in.* = $5\frac{1}{2} = \frac{11}{2}$ *f.* and 9 *in.* = $\frac{9}{12} = \frac{3}{4}$ *f.*, the area = $\frac{11}{2} \times \frac{3}{4} = \frac{33}{8} = 4\frac{1}{8}$ *sq. f.* = 4 *sq. f* 18 *sq. in.* Or else by decimal fractions, since 5 *f.* 6 *in.* = 5 5 *f.* and 9 *in.* = .75 *f.*, the area = 5.5 × .75 = 4.125 *sq. f.* = 4 *sq. f.* 18 *sq. in.*

Ex. 2. Required the area of a square ABCD, (Fig. 2.) whose side AB is $10\frac{1}{2}$ inches.

Here $10\frac{1}{2} \times 10\frac{1}{2} = 10.5 \times 10.5 = 110.25$ square inches is the area.

Ex. 3. Find the area of a parallelogram ABCD, (Fig. 3.) whose length AB = 37 feet, and breadth DE = $5\frac{1}{4}$, or 5.25 feet. Here 37 × 5.25 = 194.25 square feet = 21.583 square yards is the area.

Case II. When the two adjacent sides and the angle they contain are given.

Rule. *Radius is to the product of the sides as the sine of the angle they contain to the area.*

In the parallelogram ABCD, (Fig. 3.) draw the perpendicular DE. Then rad. : sin. A : : AD : DE, (See Trigonometry); but AD : DE : : AB × AD : : AB × DE, (See Geometry, 3d Prop. of 4th Sect.); and by Rule 1, AB × DE is the area, therefore Rad. : Sin. A : : AB × AD : area.

Ex. The sides of a rhomboid are 12 feet 4 inches and 15 feet, and the angle between them is 42° 15′, what is its area?

		Rad.	10.00000
Log.	Ft. In.	Sin. 42° 15′	9.82761
	12 4 =	12.333	1.09107
		15	1.17609
	The area . .	124.38 *sq. feet.*	2.09477

Problem II.

To find the area of a triangle.

Case I. When the base and perpendicular are given.

Rule. *Multiply the base by the perpendicular, and half the product will be the area.* Geo. 6. 4.

Ex. The base of a triangle is 250 yards, and the perpendicular 52 yards 2 feet: Find the area.

Reducing the feet to the fraction of a yard, we have 52 *y.* 2 *f.* = $\frac{158}{3}$ *yards.* The area = $\frac{250 \times 158}{2 \times 3} = 6583\frac{2}{3}$ square yards.

Case II. When the two sides and the included angle of a triangle are given to find the area.

Rule. *Radius is to the sine of the included angle as the product of the sides to twice the area.*

This rule follows immediately from Rule 2. for finding the area of a parallelogram.

Ex. Two sides of a triangle are 14 38 and 12.9 chains, and the included angle is 72° 20′, what is its area?

	Rad.	10.00000
Log.	Sine 72° 20′	9.97902
	14.38	1.15776
	12.9	1.11059
Twice the area	17.675	2.24737

The area, . . { 8.8375 *sq. ch.*
A. R. P. Y.
= 0 3 21 12.1

Case III. When the three sides of a triangle are given to find the area.

Rule *From half the sum of the three sides subtract the sides severally. Multiply the half sum and the three remainders continually together, and the square root of the last product will be the area.*

Let ABC, (Plate CCCLXXII.) be a triangle, produce AB one of its sides, and take BD and B *d* each equal to BC; join CD, and C *d*, and through A draw a line parallel to BC, meeting CD and C *d* produced in E and *e*. The angle AED will be equal to BCD. (Geo. 21.1.) which is equal to the angle BDC, (12.1) or ADE; therefore AE=AD (13.1) In like manner, because the angle A *e d* is equal to the angle BC *d*, (21.1) that is, to B *d* C (12.1) or A *d e*, (41.1), therefore A *e* = AD (13.1.)

From A as a centre, with AD or AE as a radius, describe a circle meeting AC in F and G; and from the same centre, with A *d* or A *e* as a radius, describe another circle meeting AC in *f* and *g*, and take FO = CG.

From this disposition of the lines it is manifest that

CF=AD+AC=AB+BC+AC=perimeter,

CO=2 CA,

F *f*=D *d*=2 BC,

F *g*=F *f*+*f* *g*=2 B *d*+2 *d* A=2 BA.

In order to abridge, let *p* represent half the perimeter, and consequently 2 *p* the whole perimeter; also let *a*, *b*, *c* denote the sides opposite to the angles A, B, C respectively; then it follows that

CF=2 *p*.

CG=FO=CF—CO=2 *p*—2 *b*,

C *f*=CF—F *f*=2 *p*—2 *a*.,

C *g*=CF—F *g*=2 *p*—2 *c*.

Draw BH and B *h* perpendicular to CD and C *d*, and because BD, BC, B *d* are equal, the point C is in the circumference of a circle, of which D *d* is the diameter, therefore CD and C *d* are bisected at H and *h*, (6.2) and the angle DC *d* is a right angle, (19.2) hence the figure CH B *h* is a rectangle, and B *h*=C— = ½ CD, also BH =C*h*=½ C *d*. (26.1.)

Join BE, B e; and because E e is parallel to BC, the triangle BAC is equal to each of the triangles BEC, B e C, (0 4.) But the triangle BEC is equal to $\frac{1}{2}$ EC× BH, (2.4) that is to $\frac{1}{4}$ EC×C d; and in like manner the triangle B e C is equal to $\frac{1}{2}$ e C×B h, that is, to $\frac{1}{4}$ e C × CD; therefore the triangle ABC is equal to $\frac{1}{4}$ EC×C d, and also to $\frac{1}{4}$ e C×CD.

Now since CD : C d : : CE×CD : CE×C d (3.4.)
and also CD : C d : : C e×CD : C e×C d;

therefore CE×CD : CE×C d : : C e× CD : C e ×Cd; that is, because CE × CD = FC × CG, (29.4.) and C e×C d = fC × C g, FC × CG : CE × C d : : C e × CD : f C × C g.

From this proportion, by taking one-fourth of each term, and putting the triangle ABC for its equivalent values $\frac{1}{4}$ CE×C d, and $\frac{1}{4}$ C e×CD, we also have $\frac{1}{2}$ FC× $\frac{1}{2}$ CG : trian. ABC : : trian. ABC : $\frac{1}{2}$ f C × $\frac{1}{2}$ C g

Instead of $\frac{1}{2}$ FC, $\frac{1}{2}$ CG, $\frac{1}{2}$ f C, $\frac{1}{2}$ C g, substitute their values found above, and the proportion becomes

$p \times (p-b)$: trian. ABC : : trian. ABC : $(p-a)$ $(p-c.)$

Hence it appears that *the triangle is a mean proportional between two rectangles, one contained by half the perimeter, and the excess of half the perimeter above one of the sides, and the other contained by the excesses of half the perimeter above the other two sides.*

The rule is got from this theorem, by considering that the mean of three proportionals is the square root of the product of the extremes.

Note.—This rule is particularly well adapted to logarithmic calculation.

Ex. 1. The sides of a triangle are 24, 36, and 48, chains. Find the area.

$$a=24$$
$$b=36$$
$$c=48$$
$$2s=108$$
$$s=54$$
$$s-a=30$$
$$s-b=18$$
$$s-c=6$$

$$s\times(s-a)\times(s-b)\times(s-c)=54\times30\times18\times6=174960,$$

$\sqrt{174960}$=418.282 square chains the area.

Or, by logarithms,

$s=54$	1.73239
$s-a=30$	1 47712
$s-b=18$	1.25527
$s-c=6$	0.77815
	2)5 24293
The area = 418.28 sq. ch.	2.62146

PROBLEM III.

To find the area of a trapezoid.

Note. A trapezoid is a quadrilateral, of which two opposite sides are parallel, but not equal.

Rule. Multiply the sum of the parallel sides by the perpendicular distance between them, and half the product is the area.

In the trapezoid ABCD, (Plate CCCLXXII. Fig. 5.) draw the diagonal AC, and from its extremities draw AE, CF at right angles to the parallel sides DC, AB. The figure is made up of the triangles ACB, CAD; the area of the former is $\frac{1}{2}$ AB×CF, and that of the latter $\frac{1}{2}$ CD×AE, or $\frac{1}{2}$ CD×CF, because AE=CF: therefore the area of the trapezoid is $\frac{1}{2}$ AB×CF+$\frac{1}{2}$ CD×CF = $\frac{1}{2}$ (AB+CD) ×CF.

Ex. Let AB and CD, the parallel sides of a trapezoid, be 7.5 and 12.25 chains respectively, and CF their perpendicular distance 15.4 chains. What is the area?

7.5+12.25=19.75 the sum of the par. sides.

$$\frac{19.75\times15.4}{2}=152.075 \text{ sq. ch.} = 15 \text{ ac. } 33.2 \text{ poles the area.}$$

PROBLEM IV.

To find the area of a trapezium.

Case 1. When a diagonal, and perpendiculars on it, from the opposite angles are given.

Rule. Multiply the diagonal by the sum of the perpendiculars, if they are on opposite sides of the diagonal, or their difference, if they are on the same side, and half the product is the area.

For the trapezium ABCD, (Plate CCCLXXII. Fig. 6.) is the sum of the triangles, ABC, ADC, the areas of which are by Prob. 2. Rule 1.

$$\tfrac{1}{2}\text{ AC}\times\text{BE}+\tfrac{1}{2}\text{ AC}\times\text{DF}=\tfrac{1}{2}\text{ AC}\times(\text{BE}+\text{DF}).$$

In this figure the perpendiculars are on opposite sides of the diagonal; but the truth of the rule may be shewn in the same way when they are on the same side.

Ex. The diagonal of a trapezium is 20 feet, and the perpendiculars on opposite sides of it are 4.2 feet and 3.8 feet; find the area.

4.2+3 8=8 the sum of the perpendiculars.

$$\frac{8\times20}{2}=80 \text{ sq. feet the area.}$$

Case II. When the two diagonals and the angle they make with each other are given.

Rule. Radius is to the sine of the angle contained by the diagonals as their product to double of the area.

The trapezium ABCD, (Plate CCCLXXII. Fig. 7.) is made up of the triangles BEC, CED, DEA, AEB. The doubles of the areas of the two first, by Prob. 2. Case 2. are BE × EC × sin. E and DE × EC × sin. E (supposing rad. = 1,) and twice their sum is BD×EC× sin. E. In like manner, twice the sum of the triangles BEA, AED is BD × AE × sin. E, therefore twice the whole area is

$$\text{BD}\times\text{EC}\times\text{sin. E}+\text{BD}\times\text{AE}\times\text{sin. E}=\text{BD}\times\text{AC}\times\text{sin. E}.$$

Ex. The diagonals of a trapezium are 326.8 and 269.2 feet, and they contain an angle of 54$\frac{1}{2}$°, how many square yards are in the area?

rad	10 0000
sin. 54° 30′	9.91069
269.2	2.43008
326.8	2 51428
twice area 71621.5	4.85505

area 35810.7 sq. feet.

PROBLEM V.

To find the area of a regular polygon.

Note. A polygon is said to be regular when its sides are equal, also its angles.

Rule. Radius is to the tangent of half the angle contained by two adjacent sides of the polygon, as half the side to the radius of the inscribed circle; and the area of the polygon is equal to the rectangle contained by half the perimeter and the radius of the inscribed circle.

From C, (Plate CCCLXXII. Fig. 8.) the centre of the inscribed circle, draw CD perpendicular to the side AB, and join CA. CB. Then CD will be the radius of the circle, and AB will be bisected in D, also the angles at A and B will be bisected by AC and BC.

In the right angled triangle ADC rad. : tan. A : : A D : DC, (Trigonometry); hence the truth of the first part of the rule is evident.

Again, since the polygon is equal to the triangle ACB taken as often as the figure has sides, and this space is manifestly equal to a rectangle contained by CD and $\frac{1}{2}$ AB taken as often as the figure has sides, that is, to CD and half the perimeter of the figure, therefore the area of the polygon is equal to a rectangle contained by CD and half its perimeter.

Ex. Find the area of a hexagon, the side being 20 yards. In this case, half the angle of the polygon is 60°.

Rad.	10.00000
Tan. 60°	10.23856
Half the side, 10	1.00000
Log. of rad. of ins. circle	1.23856
Half per. 60	1.77815
1039.23	3.01671

PROBLEM VI.

To find the area of any rectilineal figure.

RULE. Resolve the figure into triangles and trapezoids, and compute their areas separately; the sum will be the area of the rectilineal figure, as is sufficiently evident.

PROBLEM VII.

To find the diameter and circumference of a circle, the one from the other.

RULE 1. As 7 is to 22, so is the diameter to the circumference nearly.

As 22 is to 7, so is the circumference to the diameter nearly.

RULE 2. As 113 is to 355, so is the diameter to the circumference nearly.

As 355 is to 113, so is the circumference to the diameter nearly.

RULE 3. Multiply the diameter by 3.1416, the product is the circumference nearly.

Divide the circumference by 3.1416, the quotient is the diameter nearly.

The truth of these rules will appear from Prop. 10. of Sect. V. GEOMETRY.

Ex. 1. The diameter of a circle is 12 feet, what is its circumference?

By rule 1st, $7 : 22 : : 12 : \frac{12 \times 22}{7} = 37.71$ feet nearly, the circumference.

By rule 3d, $3.1416 \times 12 = 37.6992$, nearer to the truth.

By rule 2d, $113 : 355 : : 12 : \frac{12 \times 355}{113} = 37.699115$, still nearer.

Ex. 2. The circumference of a circle is one pole, or $5\frac{1}{2}$ yards, what is its diameter?

$$\frac{5.5}{3.1416} = 1.757 \text{ yards. The diameter.}$$

PROBLEM VIII.

To find the length of any arc of a circle.

RULE 1. Find the number of degrees in the arc; then as 180° is to that number, so is 3.1416 times the radius to the length of the arc.

By Prob. 7.—3.1416 times the radius is half the circumference, which is an arc of 180°; and the arcs of a circle have the same ratio as their measures expressed in degrees.

Ex. Required the length of the arc ADB, (Plate CCCLXII. Fig. 9.) whose chord AB is 6, the radius being 9?

From C, the centre, draw CD, bisecting the arc; this line will be perpendicular to the chord, and will bisect it. (GEO. 6. 2.)

By Trigonometry. CA = 9 Ar. Comp.	9.04576
is to AP = 3	0.47712
as rad.	10.00000
To sin. ACP = 19° 28$\frac{1}{3}$′	9.52288
Hence ACB = 38° 56$\frac{2}{3}$′ =	38.944

Again,

$$180 : 38.944 : : 3.1416 \times 9 : \frac{38.944 \times 3.1416 \times 9}{180} = 6.117 = ADB.$$

RULE II. A near approximation to any arc of a circle may be found by this proportion,

$$9\ rad. + 6\ cos.\ a. : 14\ rad. + cos.\ a. : : sin.\ a. : arc.\ a.$$

This approximation was investigated as follows:

Supposing the radius of the circle to be unity, let us assume the equation,

$$A \text{ sin. } a + B \text{ sin. } 2a = a(C + D \text{ cos. } a),$$

in which A, B, C, D are numbers to be presently determined, and as we are seeking only an approximation to the arc, let us suppose it to be such a fraction of the radius that its 7th and higher powers may be neglected. Then by well known expressions for the sine and cosine of an arc. See ARITHMETIC OF SINES, § 29.

$$\left.\begin{aligned} \text{Sin. } a &= a - \frac{a^3}{6} + \frac{a^5}{120} \\ \text{Sin. } 2a &= 2a - \frac{8a^3}{6} + \frac{32a^5}{120} \\ a \text{ Cos. } a &= a - \frac{a^3}{2} + \frac{a^5}{24} \end{aligned}\right\} \text{nearly.}$$

Let these values of sin. a, sin. 2 a, and a cos. a, be substituted in the assumed equation, and then, by making the co-efficients of like powers of a equal to each other, we find

$$A + 2B = C + D, A + 8B = 3D, A + 32B = 5D;$$

$$\text{and hence } A = \frac{7D}{3}, B = \frac{D}{12}, C = \frac{3D}{2}.$$

These values of A, B, C being substituted in the assumed equation, and 2 Sin. a Cos. a put instead of Sin. 2a, we have

$$\text{Sin. } a\ (14 + \text{cos. } a) = a\ (9 + 6 \text{ cos. } a).$$

Hence the truth of the rule is evident.

Taking the same example as in last problem, we have rad. $=9$, and sin. $\frac{1}{2}a=3$; hence cos. $\frac{1}{2}a=\sqrt{}$ rad. ^{2} — sin.$^2\frac{1}{2}a)=\sqrt{72}=8.48528$, and we have by the rule $131.91168 : 134.48528 :: 3 : \frac{134.48528 \times 3}{131.91168} = 3.05853 = \frac{1}{2}a$.

Hence the length of the arc is 6.11706; this value is true to the last figure.

Note. For another approximate value to an arc of a circle, see Geometry, Prop. II. Sect. 5. Part 1.

Problem IX.

To find the area of a circle.

Rule 1. Multiply the radius by half the circumference, the product is the area.

Note. This rule also applies to a sector of a circle.

Rule 2. Multiply the square of the diameter by the number .7854, the product is the area.

The first rule has been demonstrated in Geometry, Prop. VII. Sect. 5. Part I.

If the diameter be supposed $=1$, the circumference will be 3.1415927 (10.5), and the area,

$=\frac{1}{2}$ diam. $\times \frac{1}{2}$ circum. $=.7853982=.7854$ nearly.

And since (8.5) circles are as the squares of their diameters, 1×1, or 1, will be to the square of the diameter of any circle as .7854 to the diameter of that circle: Hence Rule 2. is formed.

Ex. Find the area of a circle whose diameter is 12 feet.

In this case half the circumference is $3.1416 \times 6 = 18.8496$ feet, and the area, by rule 1,

$18.8496 \times 6 = 113.0976$ sq. feet the answer.

Or, by Rule 2, the area is $.7854 \times 144 = 113.0976$ sq. feet.

Problem X.

To find the area of any sector of a circle.

Rule I. Multiply the radius, or half the diameter, by half the arc of the sector, and the product will be the area, as in the whole circle.

Rule II. As 360° is to the degrees in the arc of the sector, so is the area of the whole circle to the area of the sector.

The first of these rules is contained in the last problem, and the truth of the second is sufficiently evident.

Ex. Required the area of a sector CADB, (Fig. 9) the angle ACB at the centre being 18°, and the diameter three feet.

By Prob. 7, $3.1416 \times 3 = 9.4248$ the whole circumference; and by Prob. 8, 360 : 18 :: 9.4248 :: 47124 the arc of sector: Hence, by Rule 1, $.47124 \times .75 = .35343$, the area of the sector. Otherwise, by Prob. 9, the area of the circle $= .7854 \times 9 = 7.0686$; and by Rule 2, 360 : 18 :: 7.0686 : .35343, the area of the sector.

Problem XI.

To find the area of the segment of a circle.

Rule. Find by the last problem the area of the sector having the same arc as the segment, also the area contained by the chord of the arc, and the two radii of the sector, their sum, or difference, according as the segment is greater or less than a semicircle, will be the area of the sector.

The reason of this rule is sufficiently evident.

Ex. Find the area of the segment ADB, Fig. 9. which is less than a semicircle, its chord AB being 12, and the radius AC or BC 10.

By Trig. AC : AP :: rad. : sin. ACP $=36° 52'.2 = 36° 87$, the degrees in the Angle ACD; and their double, $73.74 =$ the degrees in the arc ACB. Now, $.7854 \times 400 = 314.16$. the area of the whole circle: Therefore 360° : 36° 87 :: 314.16 : 64.3504 = area of the sector CADB. Again, the three sides of the triangle ACB being 10, 10, and 12; its area (Prob. 2, Rule 3.) will be $\sqrt{(16 \times 6 \times 6 \times 4)} = 48$. Therefore the area of the segment $= 64.3504 - 48 = 16.3504$.

Problem XII.

To find the area of any segment of a Parabola.

Rule. Multiply the base of the segment by its height, and take $\frac{2}{3}$ of the product for the area.

The truth of this rule is proved in Conic Sections, Sect. 7. Prop. 1.

Ex. The base AB, (Plate CCCLXXII. Fig. 10.) of a parabolic segment ACB is 10, and its altitude CD is 6. Hence, by the rule,

The area $= \frac{2}{3} \times 18 \times 6 = 40$.

Problem XIII.

To find the area of an ellipse.

Rule. Multiply the product of the two axes by the number .7854 for the area.

Let a denote the transverse axis AB, (Fig. 11.) and b the conjugate axis CD; the area of a circle that has a for its diameter is $.7854\,a^2$ (Prob. 9.) And a is to b as the area of this circle to the area of the ellipse, (Conic Sections, Sect. VII. Prop. 3.) that is,

$a : b :: .7854\,a^2$: area of ellipse.

Hence area of ellipse $= .7854\,a\,b$.

Ex. The area of an ellipse, whose axes are 10 and 8 feet, is required.

$10 \times 8 \times .7854 = 62.832$ *sq. feet.*

Note. 1. Rules for computing the areas of elliptic and hyperbolic sectors may be derived from the investigations given in Conic Sections, Sect. VII. Prop. 3, 4, and 5.

Note 2. Rules for hyperbolic areas are also investigated in Fluxions, Art. 150.

Problem XIV.

To find nearly the area of a figure bounded by a straight line BQ, two straight lines BA, QP perpendicular to BQ, and any curve line A $a\,a'\,a''$ . . . . P.

Rule. Let BQ, (Plate CCCLXXII. Fig. 12.) the base of the figure, be divided into any number of equal parts by the perpendiculars $b\,a$, $b'\,a'$, $b''\,a''$, &c. which meet the curve in $a\,a'\,a''$, &c.

Let F denote the first perpendicular.

L . . . . the last.

E . . . { the sum of the remaining even perpendiculars, viz. $a\,b$, $a''\,b''$, &c. the 2d, the 4th, &c.

O . . . { the sum of the remaining odd perpendiculars, viz. $a'\,b'$, $a'''\,b'''$, &c. the 3d, the 5th, &c.

D . . . . the common distance between the perpendiculars.

The area of the figure will be nearly equal to

$$\tfrac{1}{3}\,\mathrm{D} \times (\mathrm{F} + \mathrm{L} + 4\,\mathrm{E} + 2\,\mathrm{O}).$$

And the approximation will be so much the more accurate, according as the number of the perpendiculars is the greater.

To prove this rule, join the tops of the first and third perpendiculars by the line A a, meeting the second perpendicular in E, and through a draw CD parallel to A a', meeting AB and $a'\,b'$ in C and D. The space bounded by the curve A $a\,a'$, and the straight lines AB, B b', $b'\,a'$ is made up of the trapezoid AB $b'a'$ and the space contained by the arc A $a\,a'$, and its chord A a'; now, if the arc be small, it may be considered as a parabolic arc, and then the curvilineal space between the arc and its chord will be $\frac{2}{3}$ of the parallelogram ACD a' (Conic Sections, Sect. vii. Prop. I.) Therefore the space A $a\,a'b'$ B will be nearly the sum of the trapezoid AB $b'a'$, and $\frac{2}{3}$ of the parallelogram ACD a'; that is, the sum of $\frac{1}{3}$ of the trapezoid AB $b'\,a'$, and $\frac{2}{3}$ of the trapezoid CBb'D.

Now, Trap. AB $b'\,a'$ = (AB + $a'b'$) B b (Geom. Part I. Sect. 4. Prop. 7.)

And Trap. CB b' D = (CB+D b') B b = 2 $a\,b$ × B b;

Therefore the area of the space A $a\,a'\,b'$ B is nearly

$$= \left\{\tfrac{1}{3}(\mathrm{AB} + a'b') + \tfrac{4}{3}\,a\,b\right\}\ \mathrm{B}\,b$$

$$= \tfrac{1}{3}\,(\mathrm{AB} + 4\,a\,b + a'b')\ \mathrm{B}\,b.$$

In like manner, it may be shewn that the space $a'b'b'''\,a'''$ is nearly

$$= \tfrac{1}{3}\,(a'b' + 4a''b'' + a'''b''')\ \mathrm{B}\,b,$$

and that the space $a'''b'''$ PQ

$$= \tfrac{1}{3}\,(a'''b''' + 4a^{\mathrm{iv}}\,b^{\mathrm{iv}} + \mathrm{PQ})\ \mathrm{B}\,b,$$

and so on; hence the area of the whole figure, which is made up of these, is

$$\tfrac{1}{3}\,\mathrm{B}\,b \times \left\{\begin{array}{l}\mathrm{AB} + \mathrm{PQ} \\ + 4\,(a\,b + a''\,b'' + a^{\mathrm{iv}}\,b^{\mathrm{iv}}) \\ + 2\,(a'\,b' + a'''\,b''')\end{array}\right\}$$

as was to be demonstrated

Ex To find the area of the space ABC, (Plate CCCLXXII, Fig. 13) supposing it to be a quadrant of a circle, the radius of which is = 1.

Let the sector BCE be one-third of the quadrant, draw ED perpendicular to AC, then CD=cos. 30°=½ CA. Divide CD into four equal parts, and draw the perpendiculars $r\,s$, $p\,q$, $m\,n$.

Because CA=1, therefore CD=½, C r=$\frac{3}{8}$, C p=¼, Cm=$\frac{1}{8}$; hence DE=$\sqrt{(1-\frac{1}{4})}$=$\frac{1}{2}\sqrt{3}$, and in like manner, $r\,s$=$\frac{1}{8}\sqrt{55}$, $p\,q$=$\frac{1}{4}\sqrt{15}$, $m\,n$=$\frac{1}{8}\sqrt{63}$. Therefore,

F+L=1+½ √3	=1 8660
4 E=½√55+½√63	=7.6767
2 O=½√15	=1.9365
The sum - -	=11.4792
Multiply by ⅓ D	= $\frac{1}{24}$
The product	= .4783
Subtract the triangle CDE	= .2165
The sector CEB	= .2618
The triple of which is the quad. ABC	= .7854

SECTION II.

MENSURATION OF SOLIDS.

Problem I.

To find the surface of a right prism or cylinder, (Plate CCCLXXII. Fig. 14, 15.)

Rule. Multiply the perimeter of the end by the length or height of the solid, and the product will be the surface of all its sides. To this, when the whole surface of the prism is required, the areas of the ends must be added.

If the plane surfaces which form the sides of an upright prism were extended into one plane, it is manifest, that the surface thus formed would be a rectangle, having one of its sides equal to the height of the prism, and its other side equal to the perimeter of the end; Hence, the truth of the rule is manifest in the case of any right prism. A cylinder may be regarded as the limit of all prisms which can be inscribed in, or circumscribed about its base, therefore, its surface will be the limit of their surfaces; now, the expression for the limit is evidently the product of the circular base by the height.

Ex. 1. How many square yards are in the surface of the walls of a room of any prismatic form, whose height is 10 feet, and circumference 58 feet?

10 × 58 = 580 sq feet = 64$\frac{4}{9}$ sq. yards the answer.

Ex. 2. What is the convex surface of a cylindrical pillar 12 feet long and one foot in diameter?

The circumference of the base, is 3.1416 feet. (Prob. 7. Sect. 1.) And the surface of the pillar 3.1416 × 12 = 37.6992 sq. feet.

Problem II.

To find the surface of a right pyramid or cone. (Plate CCCLXXII, Fig. 16, 17.)

Rule. Multiply the circumference of the base by the slant height, and half the product will be the surface of the sides; to which the area of the end may be added when the whole surface is required.

The truth of the rule will be evident, if it be considered that the faces of the pyramid are equal triangles, having the slant side of the pyramid for their altitude, and that a cone may be considered as a pyramid having an infinite number of sides.

Ex. 1. The slant height of a triangular pyramid ABCD is 20 feet, and each side of the base 3 feet. What is its upper surface?

$$\frac{3 \times 3 \times 20}{2} = 90 \text{ feet the surface.}$$

Ex. 2. Required the convex surface of a cone, the slant height being 5 feet, and the diameter of the base 3 feet.

3 × 3.1416 = 9 4248 the circumference,

½ × 9.4248 × 5 = 23.562 sq. feet the surface.

Problem III.

To find the surface of the frustum of a right pyramid or cone, that is the lower part, when the top is cut off by a plane parallel to the base. (Plate CCCLXXII, Fig. 18.)

Rule. Add together the perimeters of the two ends, and multiply the sum by the slant height, and take half the product for the surface.

For the surface is equivalent to a trapezoid, whose parallel sides are the perimeters of the ends, and height is the slant surface.

Ex. Find the surface of AG, the frustum of a square pyramid, the slant height KE being 10 feet; each side of the greater end AC 3 feet 4 inches, and each side of the lesser end EG 2 feet 2 inches.

Here $3\frac{1}{3} \times 4 = 13\frac{1}{3}$ the perim. of greater end.

$2\frac{1}{6} \times 4 = 8\frac{2}{3}$ the perim. of lesser end.

Their sum = 22 feet.

And $\frac{22 \times 10}{2} = 110$ feet the answer.

Problem IV.

To find the solid content of any prism or cylinder.—(Plate CCCLXXII, Fig. 14, 15.)

Rule. Multiply the area of the base or end by the perpendicular height, and the product will be the solid content.

This rule follows from Geom. Part 2. Sect. 2. Prop. 11. and Sect. 3. Prop. 2.

Ex. 1. The sides of the base of a triangular prism are 3, 4 and 5 feet, and its height is 12 feet: What is its solid content?

By rule 2, of Problem 2. Sect. 1. the area of the base is

$$\sqrt{(6 \times 1 \times 2 \times 3)} = 6 \text{ sq. feet.}$$

Hence the solid content $= 6 \times 12 = 72$ cubic feet.

Ex. 2. The Winchester bushel is a cylinder $18\frac{1}{2}$ inches in diameter, and 8 inches deep: What is its solid content?

The base $= .7854 \times 18.5^2 = 268.803$ sq. inches, Part 1. Prob. 9.

Therefore the solid content $= 268.803 \times 8 = 2150.424$ cubic inches.

Problem V.

To find the solid content of any pyramid or cone.—(Plate CCCLXXII, Fig. 16, 17)

Rule. Multiply the area of the base by the height, and one third of the product is the solid content.

This rule has been proved in Geometry, Part. II. Sect. 2. Prop. 17. and Sect 3. Prop. 3.

Ex. Each side of the base of a triangular pyramid is 3 feet, and its height is 10 feet: What is the solid content?

By Prob 2. of Sect. 1. the area of the base $= 3.89711$ square feet.

Hence $\frac{3.89711 \times 30}{3} = 38.9711$ cubic feet the solid content.

Ex. 2. The diameter of the base of a cone is 8 inches, and its height is a foot. What is its content?

The area of the base $= .7854 \times 8 = 6$ 2832 sq. inches.

And the solid content $= \frac{6\ 2832 \times 12}{3} = 25.1328$ cubic inches.

Problem VI.

To find the solid content of the frustum of a pyramid or cone. (Plate CCCLXXII. Fig. 18.)

Rule. Add into one sum the areas of the two ends and the mean proportional between them, (that is, the square root of their product) and one-third of that sum will be a mean area, which, multiplied by the perpendicular height of the frustum, will give the solid content.

Investigation. Let ABCD be the base of the frustum, EFGH its top, P the vertex of the pyramid, and PM a perpendicular on the base, meeting the top in L.

Let S denote the side of a square equal to the base, s the side of a square equal to the top, put H to denote LM the height of the frustum, and put r for PL the remainder of the perpendicular. By last problem, the content of the whole pyramid is $\frac{1}{3}S^2(H+r)$, and the content of the part above the frustum is $\frac{1}{3}s^2r$, hence the frustum, which is their difference, is

$$\frac{1}{3}S^2(H+r)-\frac{1}{3}s^2r=\frac{1}{3}S_2H+\frac{1}{3}(S^2-s^2)r$$
$$=\frac{1}{3}S^2H+\frac{1}{3}(S+s)(S-s)r$$

Now the base ABCD$=S^2$, and the top EFGH$=s^2$ being similar figures (Geom. Part. II. Sect. 2. Prop. 13.) they are to one another as the squares of their like sides; (Geom. Part. I. Sect. 4. Prop. 27.) that is, $S^2 : s_2 :: AB^2 : EF^2$; hence $S : s :: AB : EF$. But because of the similar triangles PAB, PEF, AB : EF :: AP : EP, and, again, (Part II. Sect. 1. Prop. 12.) AP : EP :: (MP : LP ::) $H+r : r$, therefore, $S : s :: H+r : r$, and $S-s : s :: H : r$, hence, $(S-s)\,r=sH$. This value of $(S-s)\,r$ being substituted in the expression given above for the solidity of the frustum, it becomes

$$\frac{1}{3}S^2(H+\frac{1}{3}(S-s)\,sH=\frac{1}{3}(S^2+Ss+s^2)H.$$

If it be now remarked that the product or rectangle Ss is a mean proportional between S^2 and s^2, the top and bottom of the frustum, it will appear that the formula just found gives the rule.

Ex. The areas of the ends of a frustum of a pyramid or cone are 41.57 and 23.38 square feet, and its height is 9 feet: Find its solid content.

The greater end	=	41.57
The lesser	=	23.38
The mean $=\sqrt{(41.57 \times 23.38)}$	=	31.18
		3)96.13
The mean area		32.04

$32.04 \times 9 = 288.36$ cubic feet the solid content.

Problem VII.

To find the surface of a sphere, or of any segment or zone of it.

Rule. Multiply the circumference of the sphere by the height of the part required, and the product will be the curve surface, whether it be a segment, a zone, or the whole sphere.

This rule has been investigated in Fluxions (§163.) We shall here give a different investigation.

Let HIKL (Plate CCCLXXII, Fig. 19,) be a square described about a circle, and AB a diameter joining two opposite points of contact. Take D d an indefinitely small arc, and draw DE, de perpendiculars to AB, and produce them to meet the side of the square in F and f. Suppose now the circle and square to revolve about AB as an axis; the circumference will generate a spherical surface, and the side of the square will generate a cylindric surface. Let s denote the spherical zone generated by the arc d D, and c the corresponding cylindric surface generated by the straight line F f; also, put n for 3.1416. Then, since D d, on account of its smallness, may be reckoned a straight line, s may be regarded as the surface of a frustum of a cone. Hence, by Prob. 7. of Part I., and Prob. 5 of this Part.

$s = \frac{1}{2}(n \times 2DE + n \times 2\,d\,e) \times D\,d,$

That is, because DE and $d\,e$ are almost equal,

$s = 2\,n \times DE \times D\,d:$

In like manner, $c = 2\,n \times FE \times F\,f;$

Therefore, $s : c :: DE \times D\,d : FE \times F\,f.$

Draw DG perpendicular to $d\,e$. and DC to the centre, and because of the similar triangles DG d, DEC,

D d : DG : : CD : DE ; or D d : F f : : EF : ED

Hence DE×D d=FE×F f, and therefore $s = c$:

Thus it appears that the corresponding indefinitely small elements of the spheric and cylindric surfaces are always equal, and hence, that any finite portions of them comprehended between planes perpendicular to the axis AB will be equal; so that the truth of the rule is evident.

Ex. 1. What is the superficies of a globe 6 feet in diameter?

First 6×3.1416=18.8496=the circumference.

Then 18.8496×6=113.0976 square feet the superficies.

Ex. 2. What is the convex surface of a segment, 2 feet in height, and cut off from the same globe.

18.8496×2=37.6992 square feet the surface.

Problem VIII.

To find the solid content of a sphere.

Rule I. Multiply the area of a great circle of the sphere by the diameter, and $\frac{2}{3}$ of the product is the solid content.

Rule II. Multiply the cube of the diameter by the decimal .5236, and the product is the content.

The first rule has been demonstrated in Geometry, Part II. Sect. 3. Prop. 6. The second is deduced from the first, thus: put d for the diameter, then .7854 d^2= area of a great circle (Prob. 9. Part I.) and by Rule I. $\frac{2}{3}\,d \times .7854\,d^2 = .5236\,d^3 =$ the solidity.

Ex. What is the content of a sphere 2 feet in diameter?

Answer $2^3 \times .5236 = 4.1888$ cubic feet.

Problem. IX.

To find the solid content of a spherical segment.

Rule. From three times the diameter of the sphere, take twice the height of the segment, then multiply the remainder by the square of the height, and the product by the decimal .5236 for the content.

This rule may be derived from Ex. 3. Art. 161. Fluxions; or it may be found in a more elementary form, (Geometry, Part ii. Sect. 3, Prop. 5.) as follows:

Let CBEF (Plate CCCLXXII. Fig. 20.) be a square described about a quadrant of a circle, and CE the diagonal drawn to the centre. Draw GOHR perpendicular to the radius CF, meeting the diagonal in O, the quadrantal arc in H, and the side of the square in R. Conceive the square to revolve about CF as an axis; then BE, the side of the square, will generate a cylinder, CE, the diagonal, will generate a cone, and the quadrantal arc, BF, will generate a hemisphere, having the common axis CF. Moreover, the line GR will generate a plane, the sections of which, with the cylinder, the hemisphere, and the cone, will be circles, having GR, GH, and GO, for their radii. Now it is sufficiently evident, from the above quoted proposition in geometry, that any section of the cylinder will be equal to the sum of the corresponding sections of the cone and sphere. Hence, if we conceive the three solids to be made up of very thin cylinders having these sections for their bases, it follows that any portion of the cylinder comprehended between two planes, parallel to its base, will be equal to the sum of the corresponding portions of the hemisphere and cone.

Put d for the diameter of the sphere, h for FG the common height of the cylinder EE′R′R, the conic frustum EE′O′O, and the spherical segment HFH′, and n for the number .7854. Then the area of the common base of the cylinder EE′R′R and conic frustum EE′O′O is $n\,d^2$; and because GO=GC, the diameter of the top of the frustum will be $d-2h$, and its area $n(d-2h)^2$; also the mean proportional between the top and bottom will be $n\,d\,(d-2h$. Therefore (by Prob. 3,) the solid content of the frustum is

$$\tfrac{1}{3}\left\{ n\,d^2 + n\,(d-2\,h)^2 + nd\,(d-2\,h) \right\} \times h$$

$$= n\,(d^2 h - 2\,d\,h^2 + \tfrac{4}{3}\,h^3.)$$

Now the solid content of the cylinder is $n\,d^2\,h$ (by Prob. 1.) Therefore the spherical segment, (which is the difference of the cylinder and conic frustum) is

$$n\,(d^2 h - d^2 h + 2dh^2 - \tfrac{4}{3}h^3)$$

$$= \tfrac{2}{3}\,n\,(4\,d - 2\,h)\,h^2$$

This last formula is the analytic expression of the rule.

Ex. In a sphere whose diameter is 21 inches, what is the solid content of a segment whose height is 4.5 inches?

First, 3×21—2×4 5=54.

Then 54×4.5×4.5×.5236=57.25566 inches the content required.

Problem. X.

To find the solid content of a paraboloid, or solid produced by the rotation of a parabola about its axis. (Plate CCCLXXII. Fig. 21.)

Rule. Multiply the area of the base by the height, and take half the product for the content.

This rule has been investigated in *Fluxions*, § 161, Ex. 1.

Ex. If BC, the radius of the base of a paraboloid, be 5, and AB, its height, be 12 feet, what is its content?

First $10^2 \times .7854 = 785.4$ the area of the base;

Next 785.4×6=471.24 feet the solidity.

Problem XI.

To find the solid content of a frustum of a paraboloid.

Rule. Add together the areas of the circular ends; then multiply the sum by the height of the frustum, and take half the product for its solid content.

To prove this rule, put A and a for the ends, h for the height of the frustum, and c for the height wanted to complete the paraboloid. By last problem, the content of the complete solid would be $\frac{1}{2}$ A $(h+c)$ and that of the part cut off $\frac{1}{2}\,ac$, therefore the content of the frustum is

$$\tfrac{1}{2}\,A\,(h+c) - \tfrac{1}{2}\,a\,c = \tfrac{1}{2}\left\{ A\,h + c\,(A-a.) \right\}$$

But from the nature of the parabola A : a : : $h+c$: c and A—a : a : : h : c, hence $c\,(A-a) = a\,h$, and the content of the solid is

$$\tfrac{1}{2}\,(A\,h + a\,h) = \tfrac{1}{2}\,h\,(A+a.)$$

Ex. The diameter of CC′, the greater end of a parabolic frustum, is 58, that of DD′ the less 30, and the height 18 inches. Find the content.

The areas of the ends $= .7854\,(30^2 + 58^2) = 3348.9456$.

The content $= 3348.9456 \times 9 = 30140.5104$ cub. in.

PROBLEM XII.

To find the solid content of a parabolic spindle, or solid generated by the rotation of an arc AEB of a parabola about AB, an ordinate to the axis.

RULE. Multiply the area of the middle section by its length, and take $\frac{8}{15}$ of the product for the content of the solid.

For the investigation of this rule, see Fluxions, Art. 161, Ex. 2.

PROBLEM. XIII.

To find the solid content of a frustum of a parabolic spindle, one of the ends of the frustum passing through the centre of the spindle. (Plate CCCLXII. Fig. 22.)

Add into one sum eight times the square of the diameter of the greater end, and three times the square of the diameter of the lesser end, and four times the product of the diameters; multiply the sum by the length, and this product again by .05236 (viz. $\frac{1}{15}$ of .7854,) and the result will be the content.

Putting $p = $ CD, the abscissa of the generating curve, which is also the radius of the greater end of the frustum, $q = $ AC the semiordinate of the curve, $y = $ CR $=$ PQ the radius of the lesser end of the frustum, $x = $ PR $=$ QC its length, and $n = .7854$; it has been found (FLUXIONS, Art. 161, Ex. 2.) that the content of the frustum is

$$\frac{4\,n\,p^2}{q^4}(q^4\,x - \tfrac{2}{3}\,q^2\,x^3 + \tfrac{1}{5}x^5).$$

Now, from the nature of the curve, $PR^2 : AC^2 :: DR : DC$, that is $x^2 : q^2 :: p - y : p$, hence $q^2 = \frac{p\,x^2}{p-y}$.

Let the values of q^2 and q^4 be substituted in the above formula for the content of the frustum, it then becomes

$$\frac{4\,n\,x}{15}(8\,p^2 + 4\,p\,y + 3\,y^2,)$$

an expression from which the rule is derived.

Ex. Suppose the diameters of the ends to be 8 and 6, and the length 10; required the content.

First $8 \times 8^2 + 3 \times 6^2 + 4 \times 8 \times 6 = 812$,

Then $812 \times 10 \times .05236 = 425.1632$ the content.

PROBLEM XIV.

To find the solid content of a spheroid, or solid generated by the rotation of an ellipse about either axis. (Plate CCCLXXII. Fig. 23.)

RULE. Multiply continually together the fixed axis, the square of the revolving axis, and the number .5236 (or $\frac{1}{6}$ of 3.1416) and the last product will be the solid content.

This rule has been investigated in FLUXIONS, Art. 161.

Ex. 1. The greater axis AB of an oblong spheroid is 50, and the lesser axis CD 30, what is the solid content?

Here the greater is the fixed, and the lesser the revolving axis.

Therefore the solid content is

$50 \times 30^2 \times .5236 = 23562$ the content.

Ex. 2. What is the content of an oblate spheroid, the axes being as in last example?

$30 \times 50^2 \times .5236 = 39270$ the content.

PROBLEM XV.

To find the solid content of the frustum of a spheroid, its ends being perpendicular to the fixed axis, and one of them passing through the centre. (Plate CCCLXXII. Fig. 24.)

RULE. To the area of the less end, add twice that of the greater; multiply the sum by the altitude of the frustum, and $\frac{1}{3}$ of the product will be the content.

NOTE. This rule applies also to the frustum of a sphere.

Investigation.—Let ABE be a quadrant of an ellipse, C its centre, CAFE a rectangle circumscribed about it, and CF the diagonal. Draw any straight line DG parallel to CE, meeting AC, CF, ABE, and EF in D, H, B, G. By CONIC SECTIONS Part 1. Sect. 2. Prop. 16.

$$DB^2 : CE^2 :: CA^2 - CD^2 : CA^2,$$

and by sim. trian $DH^2 : CE^2 :: DC^2 : CA^2$.

Therefore, (GEOM Sect. 3. Prop 10.)

$$DB^2 + DH^2 : CE^2 :: CA^2 : CA^2.$$

Hence $DB^2 + DH^2 = CE^2 = DG^2$.

Suppose now the figure to revolve about AC as an axis, so that the elliptic quadrant may generate the half of a spheroid, the rectangle AE a cylinder, and the triangle ACF a cone; it is evident, as in the case of the sphere, (Prob. 9.) that every section of the first of these solids is equal to the difference of the sections of the other two; and consequently, that the frustum of the spheroid between CE and DG is equal to the difference between the cylinder having DG or CE for the radius of its base, and the cone having DH for the radius of its base, and CE for its altitude.

Put $n = 3.1416$, then (Prob. 4.) the content of the cylinder is $4\,n \times DG^2 \times CD$, and (Prob. 5) the content of the cone is $\frac{4}{3}\,n \times DH^2 \times DC$: Therefore, the difference, or the content of the spheroid, is

$$4\,n \times CD\,(DG^2 - \tfrac{1}{3}DH^2).$$

But it was shewn, that $DH^2 = DG^2 - DB^2$, therefore the content of the solid is equal to

$$\tfrac{4}{3}\,n \times CD(2\,DG^2 + DB^2),$$

and hence is derived the rule.

When the altitude becomes the semiaxis, the frustum becomes half the spheroid, which is $\frac{2}{3}$ of the circumscribing cylinder, agreeing with the rule of Prob. 12.

Ex. Suppose the greater end of the frustum to be 15, the less 9, and the length 10 inches, required the content?

The area of the gr. end $= 15^2 \times .7854$.

The area of the less $= 9^2 \times .7854$

The content $= .7854\,(9^2 + 2 \times 15^2) \times \frac{10}{3} = 1390.158$ cubic inches.

GAUGING.

The geometrical rules by which the content of any cask may be computed, form a particular branch of Mensuration called GAUGING.

Casks are usually considered as having one or other of these four forms:

1. The middle frustum of a spheroid, (computed by Prob. 15.)

2. The middle frustum of a parabolic spindle, (Prob. 13.)
3. The two equal frustums of a paraboloid, (Prob. 11.)
4. The two equal frustums of a cone, (Prob. 6.)

The content of any cask whatever may also be nearly found, in wine or ale gallons, by the following general rule :

RULE. Add into one sum 39 times the square of the bung diameter, 25 times the square of the head diameter, and 26 times the product of the diameters. Multiply the sum by the length, and the product by .00034 ; then the last product, divided by 9, will give the wine gallons, and divided by 11, will give the ale gallons.

In investigating this rule, it is assumed as a hypothesis, that one-third of a cask at each end is nearly a frustum of a cone, and that the middle part may be taken as the middle frustum of a parabolic spindle. This being supposed, let AB and CD (Plate CCCLXXII. Fig. 25.) be the two right lined parts, and BC the parabolic part. Produce AB and DC to meet in E, and draw lines as in the figure. Let L denote the length of the cask, B the bung diameter, and H the head diameter : Then, since AB and DC have the same directions as the parabolic curve BFC, at B and C, they will be tangents to the curve : Therefore $FI = \frac{1}{2} EI$. But $BI = \frac{1}{3} AK$, and hence by similar triangles $EI = \frac{1}{3} EK$; consequently $FI = \frac{1}{2} EI = \frac{1}{6} EK = \frac{1}{3} FK = \frac{1}{10} (B-H)$; so that the common diameter $BL = FG - 2 FI = B - \frac{1}{5}(B-H) = \frac{1}{5}(4B+H)$ which call C. Now, by the rules for parabolic spindles and conic frustums, we obtain (putting n for .7854.)

$$\frac{8 B^2+4BC+3 C^2}{15} \times \frac{Ln}{3} = \frac{328 B^2+44 BH+3H^2}{25\times 45} \times Ln$$

for the parabolic or middle part ; and

$$\frac{C^2+CH+H^2}{3} \times \frac{2Ln}{3} = \frac{160 B^2 + 280 BH+310 H^2}{25\times 45} \times Ln$$

for the two ends, and the sum of these two, after proper reduction, is

$$(39 B^2+26 BH+25 H^2) \times \frac{Ln}{90} \text{ nearly,}$$

for the length in inches ; and the factor $\frac{n}{90}$ or $\frac{.7854}{90}$ being divided by 231 (the inches in a wine gallon) gives $\frac{.00034}{9}$ the multiplier for wine-gallons ; and since 231 is to 252 as 9 to 11 nearly, $\frac{.00034}{11}$ will be the multiplier for ale-gallons, as in the rule.

Ex. Suppose the bung and head diameters of a cask to be 32 and 24 inches, and the length 40 inches, required the content in ale, also in wine-gallons.

Here $(39^2 \times 32^2 + 26 \times 32 \times 24 + 25 \times 24^2) \times 40 \times \cdot 00034 = 1010\cdot 5$, which being divided by 9 and by 11, we obtain 112·3 wine-gallons, or 91·9 ale gallons for the content. (ξ)

MENTZ, or MAYENCE, anciently *Moguntium*, is a city of Germany, in the Grand Duchy of Hesse. It is built nearly in the form of a semi-circle on the left bank of the Rhine, below its junction with the Maine. Mentz is one of the strongest cities in Germany. The works are numerous and strong, and of such an extent as to require a garrison of about 30,000.

The streets of Mentz are narrow and long, and the houses by no means handsome. The principal edifices are the electoral palace, which has been used as a military hospital since 1793, the house of the Teutonic Knights, and the arsenal. The principal churches are, the Cathedral and its towers, the church of Ignatius, the ruins of the church of Notre Dame, the church of the Augustines, the church of St. Peter, and the ancient church of St. Stephen. There is an university at Mentz, founded in 800, and established in 1482 by the Archbishop of Diether, besides some other literary establishments. The public library contains 80,000 volumes, and cabinets of medals, natural history, philosophical instruments, Roman monuments, and pictures.

The trade of Mentz is chiefly in French and Rhenish wines ; and its chief manufactures are those of cotton and coffee of chicory. The population is about 20,000. East Long. 8° 14′, and North Lat. 49° 58′. A very full and interesting account of Mentz, such as it was in 1789, will be found in the *Voyage sur le Rhin depuis Mayence jusqu'a Dusseldorf.* Neuwied, 1791, 2 vols.

MEQUINEZ, or MEQUINAS, the principal city in the province Fez, and the northern capital of the empire of Morocco, is situated in 34° 12′ North Latitude, and about 5° 30′ West Longitude. It stands in a beautiful valley, about 60 miles eastward from Salee, surrounded by gentle eminences and highly cultivated vales. It is an ancient town, founded about the end of the tenth century, by a tribe of the Tenctes called Mequina, who had revolted from the ruler of Fez ; but it owes its present extent and importance to Sultan Muley Ismael. After having subdued the petty kingdoms, which now form the empire of Morocco, he resolved to establish two imperial cities, in order to keep his subjects under more complete authority ; and made Mequinez the capital of the north, as Morocco was of the south. He greatly enlarged the city towards the west, and erected a beautiful palace, with many other public buildings. On the north-west, he enclosed a large space for the families of his black troops, called the Negroes Quarter, and which nearly equalled the city in extent ; but of this black town nothing now remains except the walls. Adjoining to this place is the Millah, or that part of the city inhabited by the Jews, which is walled round and in a good state of repair. On the side of the city towards the Atlas mountains, is a wall of circumvallation about six feet in height, which was built as a defence against the impetuous but momentary attacks of the Berebbers. The palace stands at the south end of the city ; and is a very extensive square, containing several well watered gardens. The buildings are all of one story, and the rooms, though narrow, are long and lofty, being about 12 feet wide, 25 long, and 18 high. The walls are inlaid with glazed tiles of bright colours, and the light is communicated by means of large folding doors. Between the different suites of apartments are courts paved with marble, some of which have a fountain in the centre ; and in different parts of the palace are separate buildings called Kobbahs, which contain a spacious square room with a pyramidal roof, curiously carved and ornamented in the inside. In the centre of the whole is the harem or seraglio, within which is a spacious garden planted with tall cypress trees ; a gallery supported by columns runs round the inside of the square, and communicates with the adjoining apartments, which terminate in a common hall or large chamber, where the females look through the iron-latticed windows, to take the fresh and perfumed air of the gardens. A hospitium, or convent of Spanish monks, was established in Mequinez by the king of Spain, about the beginning of the 18th century, for the relief and spiritual comfort of Catholic captives and Christian travellers; and was much respected by the inhabitants on account of the exemplary lives of the fathers, and the great service which they rendered to the poor by the gratuitous distribution of medicines; but the place was deserted previous to the accession of Soliman, the present emperor.

The houses of Mequinez, like those of other Mahometan towns, have no windows towards the street, except a few small holes, and open into the inner court, which are surrounded with galleries or pillars. The streets are narrow, and without any pavement; so that the mud in winter is accumulated to a degree which renders them almost impassable on foot. The inhabitants are milder in their manners than in any other part of the empire; and are extremely hospitable to strangers. The women of this town are particularly and almost universally distinguished for their beauty; so that the term Mequinasia has become a proverbial epithet for a beautiful woman. Their eyes are large, black, and sparkling, their teeth white, and their complexion of a healthy red and white, forming a striking contrast to the women of Fez, within a day's journey of them, who are generally of a sallow or pale complexion. They have also elegant forms, and possess a modesty and suavity of manners rarely met with in other places, even among the most polished nations of Europe. The population is estimated by Jackson at 110,000. See Chenier's *Present State of the Empire of Morocco;* Jackson's *Account of Morocco.* (*q*)

MERCATOR, Nicholas. See Fluxions and Mathematics.

MERCURY. See Astronomy, and Chemistry.

MERIDA, *the Augusta Emerita* of the Romans, an ancient town of Spain, in the province of Estremadura, is situated on an eminence near the River Guadiana, which is crossed by a large and good bridge. This town, which has now dwindled into insignificance, is principally celebrated for the remains which it still exhibits of Roman magnificence. The pavements of the streets, of the houses, and the churches, are so many vestiges of their works, and the wells and the cellars are filled with them. Numerous inscriptions, ruined columns, vases, capitals, friezes, statues, and basreliefs are everywhere seen. Two Roman aqueducts are still seen in ruins, and also the vestiges of a fortress. The ancient baths are in an excellent state of preservation. Besides these, there are two large reservoirs of water like lakes, called Albufera and Albuera, which appear to have been used for combats on the water. One of them, which is a league from Merida, is 90 feet long, and 51 deep. It is surrounded with thick walls, and adorned with two beautiful towers, a very fine flight of steps leading to the bottom. The other reservoir, which is 2 leagues from the town, is small, but the walls which retain the water, and the great tower which serves it for an aperture for air, are much finer. The environs of Merida abound in corn, wine, and fruits. Its population is about 4500. West Long. 6° 3′, and North Lat. 38° 48′. See Laborde's *View of Spain*, Vol. i. p. 347.

MERIDE, a *musical interval*, was so named by M. Sauveur, (see *Mem. de l'Acad.* 16mo, 1701, p. 407) as the $\frac{1}{43}$ part of the octave, $= 14.2761314\Sigma + m, = 14.2839938\,\Sigma$; its common log. is .9929993,0243; and it is equal to 7 Eptamerides, which see.

MERIDIONAL PARTS. See Navigation.

MERIONETHSHIRE, a maritime county in North Wales, is bounded on the north by Caernarvonshire and Denbighshire; it is divided in part from the former county by an immense ravine, through which flows a small river; on the east by Denbighshire and Montgomeryshire; the division of it from the latter county is partly formed by one of the most celebrated passes in Wales, called the Stoney Mile; on the west it is bounded by the Irish Sea; and on the south by Cardiganshire, from which it is divided by the river Dovey. Its form is nearly that of a triangle, the apex of which is to the south. Its length, from the vicinity of Snowdon to the confines of Montgomeryshire, is 43 miles, and from Harlech to the boundary of Llangollen parish, it is about 38 miles broad. Its circumference is about 154 miles, and its area 691 square miles, or 442,240 acres. It is divided into 5 hundreds, and contains one county town, Harlech; the other towns are Dolgelly, Bala, and Burmouth. The surface of the county, though on the whole very mountainous, is a good deal varied, as there are some lower hills, and beautiful and fertile valleys, interspersed with woods, lakes, rivers and cataracts. These circumstances, together with the grandeur of its sea views, render it one of the most romantic and picturesque of the Welsh counties. Some of the principal mountains and vales deserve a short notice. At the north-eastern angle of the county is a long chain of mountains which branches into Denbighshire and Montgomeryshire; they are called the Ferergn Mountains; their northern boundery is the Dee, and their southern the Tannad; their length from north to south is about 16 miles, and their breadth varies from 5 to 10. There are no lakes in these mountains, and no river of consequence flows from them. The fine vale of the Dee lies below them. The other most celebrated mountains are Cader Idris and the two Arrans. Cader Idris is the beginning of a chain of mountains which, beginning near the sea, about a mile above Towyn, extends in a north and north-easterly direction, and includes the Arrans. It is in height the second in all Wales. Its peak rises above the town of Dolgelly about 2,850 feet. It is very steep and craggy on every side, and nearly perpendicular on its southern, on the borders of Talyllyn lake. The breadth of this chain in no part exceeds 4½ miles, and in some parts it is a mere ridge. The loftiest of the Arrans is said to be only 120 feet below Cader Idris. Beyond this mountain, towards the sea, are round smooth hills, which form a rich and excellent sheep walk, and then meadows and bogs. To the north of Dolgelly there is a mountainous tract, containing several lakes; this tract extends to the north part of the county, which is celebrated for the beautiful vale of Festiniog This vale is scarcely 3 miles long, and not one in breadth. There are few vales which afford such delightful prospects; the hills which bound it are covered with oaks, and a small and beautiful river flows in a serpentine course through it, in the midst of rich cultivated fields. Near the vale are the falls of the Cynfaol: the upper consists of three steep rocks, over which the water falls into a black bason, which is overshadowed by other rocks; the other is formed by a broad sheet of water precipitated about forty feet. The principal lake in this county, and indeed the largest lake in all Wales, is Pemblemoer or Bala Pool, on the banks of which stands the town of Bala; from north-east to south-west it is 4 miles long; its greatest breadth is 1,200 yards. Its water is said to be so pure that the most delicate taste cannot detect any admixture. The scenery around it is mountainous, but not grand or picturesque. In stormy weather its waters are raised 8 or 9 feet, covering the adjoining vale, and sometimes threatening destruction to the town of Bala. The river Dee flows through this lake. There are several other lakes of smaller size, some of which are remarkable for the beauty of the surrounding scenery.

The principal rivers are the Dee, the Descenny, the Dyssi, the Avon, and the Dyrwhydd. The Dee has two spring heads, in the eastern part of the county, near the sides of the Arran mountain; these, after uniting and passing through the lake of Pemblemoer, run by a north-east direction into Denbighshire. The Descenny rises about 3 miles to the south of Dolgelly, and falls into the Irish sea a little to the west of Towyn; the Dyssi or Dovy rises in the west part of the county, and falls into the Irish Sea at Aberdovy. The Avon rises to the south-west of Bala, passes by Dolgelly, and falls into the Irish sea a little below Barmouth. The Dyrwhydd rises in the north of the county, on the borders of Caernarvonshire, and falls into the Irish sea about 3 miles north from Harlech. The coast of this county possesses only one port, Barmouth, which stands on a little arm of the sea, and is of difficult entrance, the bar admitting only vessels that draw 8 or 9 feet, even at high water. On the northern part of the coast adjoining Caernarvonshire, are two inlets of the sea, Troeth Bach and Troeth Maivr, having one entrance, and each receiving a small stream; the greatest part of them are dry at low water, and become quicksand. 2000 acres of the latter have lately been recovered by embanking. Tradition states, that a whole division or hundred of this county has been swallowed up by the sea, and there are appearances that strengthen it. This hundred is said to have stretched north and south 12 miles, and to have been about 5 in breadth; and to have been situated between Harlech and Barmouth. About half way between these towns is a causeway, 24 feet thick, which runs for a considerable way into the sea, the end of which is met by another causeway, which stretches out from a point to the north-west of Harlech. The space between these is supposed to have been the hundred. The inundation is said to have happened about the year A. D. 500. The natural history of this county, so far as its mineralogy is concerned, is rather interesting. The mountains consist principally of granite, porhpyry, and other unstratified rocks. The secondary hills are composed of mixed schistus; the vallies contain schistose clay, and the level parts of the county abound with peat earth. The Ferwyn mountains are composed of primitive schistus, in thick irregular laminæ, intersected in places with veins of quartz. There are large quarries of slates in those mountains. The only metals found in them are calamine and lead. Cader Idris consists of siliceous porphyry in mass, intersected by vines of quartz. Siliceous schistose porphyry also intersected by viens of quartz; argillaceous prophyry in mass, and granitell in mass. There are no mines in or near Cader Idris. The lake of Bala abounds in a variety of fish, of which the red trout and the gwyniad are the rarest and most esteemed. It is remarked that the trout in the Dee have white flesh, whereas those in the lake have theirs always red. The climate of this county is very cold, and at the same time moist, and is said to be particularly unfavourable to fruit. The soil in some part of the vallies is fruitful, but in general it is very sterile.

After having described the surface, the mountains and lakes of Merionethshire, little remains to be said of this county, for its agriculture cannot be a matter of any importance, when we reflect on the nature of its soil, surface, and climate, all of which are unfriendly to agriculture. In its valleys, potatoes, barley, and oats are cultivated on a small scale, and in an inferior manner; the pastures in these valleys are good, and the less lofty hills, especially on the sea-coast, near the mouth of the Dovey, furnish extensive and excellent sheep-walks. In other parts of the county, breeding and the dairy are attended to with some spirit and success. Though it is even at present well wooded, especially when compared with the adjoining county of Caernarvonshire, yet, formerly, from the account of Leland, it appears to have been much more thickly covered with timber. There are one or two large trees in it, which deserve notice. In the church yard of Malwydd is a remarkable yew tree: the girth of the trunk, a yard high, is 22 feet and a half, the radius of the branches 39 feet, forming a circumference of about 240 feet. The peasantry near Harlech, chaunt with the harp some verses in celebration of an oak tree, the trunk of which, 15 feet in length, and 25 in circumference, measured 609 cubic feet. From the fork it divided into several branches, 3 of which extended to the length of 45 feet. The roads of this county have been much improved within these few years. From the accounts laid before Parliament, it appears that in the year 1814, the length of the paved streets and turnpikes in this county was 206 miles 2 furlongs; and the length of all the other highways 393 miles 1 furlong. The estimated value of labour expended on their repairs, was 775*l.*; the composition money, 449*l.*; the highway rates, 180*l.*; and the money expended in law, 8*l.*; making a total of 1102*l.* for the maintenance of 599 miles three furlongs of streets and highways.

Merionethshire is celebrated for its woollen manufactures; strong cloth is made principally near Dolgelly. Almost every little farmer makes webs; and few cottages are without a loom. The cloth is generally sold on the spot, though some is still sent to Shrewsbury; a great deal is exported through Liverpool and London to Holland, Germany, and America; the rest is used at home. Stockings, wigs, socks, and gloves, are made in the town and neighbourhood of Bala; they are generally purchased by chapmen, who sell them in the adjoining English counties.

This county returns one member to Parliament; is partly in the diocese of Bangor, and partly in that of St. Asaph, and in the province of Canterbury. The following are the results of the returns to Parliament respecting its poor, for the year ending the 5th of April, 1815.

Annual value of real property	£111,436
Money raised by parochial rates	14,254
Money expended for the poor	12,096
Money in removals, suits of law, &c.	425
Money for militia purposes	50
Church rate, county rate, &c.	1713
Total expenditure	£14,285

Persons relieved out of workhouses	2213
Persons relieved in ditto	none
Occasionally in and out of ditto	386
Members of Friendly Societies	34
Annual amount of charitable donations for parish schools	£84 0
——— for other purposes	221 18

In the year 1803, the parochial rates amounted to the sum of 9,449, so that in 1815 there had been an increase of nearly 50 per cent.

The following are the results of the last population return: in the year 1700, 23,800 inhabitants; in 1750, 30,900; in 1801, 30,500, a decrease; and in 1811, 30,924; from this it appears that the population in 1811, though greater than that in 1801, scarcely exceeded that in 1750. There is one baptism to 40 inhabitants; one burial to 62, and one marriage to 129.

Houses inhabited	6220
Families occupying them	6817
Houses building	33
Houses uninhabited	115
Families employed in agriculture	3619
Families in trade	1270
All others	1928
Males	14,308
Females	16,616
Total	30,924

See Davies's *View of the Agriculture of North Wales*; Aikin's *Tour through North Wales*; and Nicholson's *Cambrian Traveller's Guide*. (W S.)

MERMAID, or MERMAN, a marine animal, the upper parts of which are supposed to resemble those of the human species, and the lower the tail of a fish.

This animal, such as it is understood to be, has never come under the observation of any intelligent naturalist, and has therefore given birth to many controversies. Artedi, however, proposes to institute a genus under which the mermaid may be comprehended with these characteristics, SIREN, Dentes . . . . . . Pinnæ *duæ tantum in toto corpore. Canda pinnata nulla.* Caput, *collum et pectus ad umbilicum usque, humanam speciem habent.* But, at the same time, he says, "I wish that some skilful ichthyologist would examine this animal, to ascertain whether it be imaginary, or a real fish; it is better to refrain from opinions, than to give them precipitately." *Bibliotheca Ichthyologica.* Others have shown less reserve, and have declared positively that the mermaid is an animal *sui generis*, narrowly resembling the human species.

The ancients describe Sirens, Tritons, and Nereids, as inhabitants of the waters; and it has been generally believed by the natives of all maritime countries, that such beings actually exist; but the discrepancies in the description by those who have seen the mermaid, or merman of modern times, are such that they cannot refer to the same animal. Some affirm it is smooth; others call it hairy; and, according to a third class, it is covered with scales. There is the like difference regarding the real figure of the animal, which is said either to have a single or divided tail; or to have none; as seems to be the case with that alluded to by Artedi.

In an early account of Newfoundland, the narrator describes a "maremaid, or mareman," which he observed within the length of a pike, as a strange creature, which came swimming swiftly towards him, "looking cheerfully on my face, as it had been a woman. By the face, eyes, nose, mouth, chin, ears, neck, and forehead, it seemed to be so beautiful, and in those parts so well proportioned, having round about the head many blue streaks resembling hair, but certainly it was no hair." The observer further remarked, that the shoulders and back, down to the middle, were square, white, and smooth, as the back of a man: and from the middle to the end, it tapered like a broad-hooked arrow. This animal put both its hands on the side of the boat wherein he sat, and strove much to get in, but was repelled by a blow. (See Whitbourne's *Discourse of Newfoundland* in fine.) Probably the narrator's imagination has embellished the appearance and the boldness of the animal. In the year 1671, another marine animal was seen by six negroes, who, being strictly examined on the subject, agreed, in general, that from the head to the middle it resembled a man, and from thence downwards a fish, terminating in a forked tail; the head, face, eyes, and mouth, were like those of a man; the nose extremely flat. Its hair, which was grey, hung over the shoulders; and the beard, also grey, was about seven or eight inches long. Grey hair covered the breast, but the throat and rest of the body were rather white. The size of the animal was about equal to that of a youth of 16 or 17. It stood half out of the water, looking boldly on the negroes, and raising its hand as if to wipe its face: it was within a few paces of them; and, after showing itself three times, plunged into the sea. De Maillet, *Telliamed*, tom. ii. p. 320.

Nearly about the same period, there was given a very distinct account of an animal referred to this tribe, though the author, an English surgeon, does not design it by any name. About three leagues from the mouth of the river Rappahannock in America, while alone in a vessel, he observed, at the distance of about half a stone throw, "a most prodigious creature, much resembling a man, only somewhat larger, standing right up in the water, with his head, neck, shoulders, breast, and waist, to the cubits of his arms, above water; his skin was tawny, much like that of an Indian; the figure of his head was pyramidal and sleek, without hair; his eyes large and black, and so were his eye-brows; his mouth very wide, with a broad black streak on the upper lip, which turned upwards at each end like mustachios. His countenance was grim and terrible. His neck, shoulders, arms, breast, and waist, were like unto the neck, arms, shoulders, breast, and waist of a man. His hands, if he had any, were under water. He seemed to stand with his eyes fixed on me for some time, and afterwards dived down; and a little after rose at somewhat a greater distance, and turned his head towards me again, and then immediately fell a little under water, that I could discern him throw out his arms, and gather them in as a man does when he swims. At last he shot with his head downwards, by which means he cast his tail above the water, which exactly resembled the tail of a fish with a broad fane at the end of it." Glover's *Account of Virginia, Ap. Phil. Trans.* vol. xi. p. 625, for 1676.

The mermaid is not confined to any quarter of the globe; for according to Debes, in 1670 one stood near the shore of the Faroe Islands, in sight of many of the inhabitants, during two hours and a half, up to the navel in the water. "Long hair hung from her head all around her, down to the surface; and she held a fish in her right hand." The modern historian of these islands, Landt, is silent on this subject.

Pontoppidan, a credulous author indeed, yet willing to take a comprehensive view of doubtful subjects, affirms, that if the existence of European mermaids be called in question, it proceeds entirely "from the fabulous stories being generally mixed with the truth." Hundreds of persons, of credit and reputation in the diocese of Bergen, maintained, with the strongest assurances, that they had seen this creature, sometimes at a distance, sometimes quite close to their boats, standing upright. It was formed like a human being down to the middle, but they could not see the rest. Nevertheless, Pontoppidan could find only a single person who had actually seen and handled one out of the water. His informer, a clergyman, said, that in the year 1719, a merman had been cast up dead on the shore, along with other fish. It was much longer than any others described. "The face resembled that of a man, with mouth, forehead, eyes. The nose was flat, and, as it were, pressed down to the face, in which the nostrils have ever been very visible. The breast was not far from the head; the arms seemed to hang to the side, to which they were joined by a thin skin, or membrane. The hands were, in appearance, like to the paws of a sea-calf." *Natural History of Norway*, vol. ii. p. 190, 191. Pontoppidan observes, that the most recent account of the animal related to the year 1723, when three ferrymen affirmed on oath, that one had been seen by them at the distance of not more than 7 or 8 fathoms. In appearance, it resembled an old man with strong limbs and broad shoulders: its skin was coarse, and very hairy. The head was small in proportion to the body, and had short curled black hair, which did not reach below the ears. The face was meagre, the eyes deep sunk, and the beard black. It stood in the same place half a quarter of an hour, exposed down to the breast, and the tail was remarked to taper like that of a fish. The men, beginning to be alarmed, retreated, when the animal, inflating its cheeks, made a kind of roaring noise, and plunged into the water. One of the same ferrymen affirmed, that 20 years before, he had seen a mermaid with long hair and large breasts. Pontoppidan adds, that a creature is often caught on the hooks of fishermen, which he inclines to call the offspring of the merman, some being as large as a child of three years old. One had been taken recently, which, in the upper parts, resembled a child, but the rest of it was like a fish. Vol. ii. p. 195.

Torfæus maintains, that mermaids are seen near the southern coast of Iceland; and according to Olafsen, two have been taken in the surrounding seas; the first in the earlier periods of the history of that island, and the second in 1733. The latter was found in the belly of a shark. Its lower parts were consumed, but the upper were entire. This creature was as large as a boy eight or nine years old; the head shaped like that of a man, with a very prominent occiput; and the forehead broad and round. The ears were situated far back, and had large lobes. On the head was long stiff black hair, hanging down to the shoulders, pretty much resembling the *fucus filiformis*. The skin above the eyelids was greatly wrinkled and bald; and throughout the body, of a clear olive colour. The eyes resembled those of a cod; and both the cutting teeth and grinders were long, and shaped like pins. The arms were of the natural proportion, and each of the five fingers connected by a large web. The neck was short, the shoulders high, and the breast and back exactly resembling those of a man. Olafsen considers the pecularities of this animal to be demonstrated in the hair, teeth, and fingers. But, from the rapid change taking place in the stomach of a shark, and the great distance it can speedily traverse, he is almost inclined to believe that these were human remains. Yet the islanders were differently impressed; for all firmly credited this creature to be the *marmenill*, by which name the mermaid is known among them. Olafsen *Voyage en Islande*, tom. iii. p. 223.

The attention of the public has been more lately attracted to accounts of mermaids, supposed to have been seen on the coast of Scotland and Iceland. According to old historians, some remarkable animals were taken on the coast of England, which were called "a triton, or man fish;" but no accurate and authentic description has been transmitted, from which we are enabled to determine regarding their nature. In the course of last century, also, a plate was engraved, we have understood, of a marine animal, by the same denomination, which was taken about the year 1746 or 1747. It is generally credited, among the inhabitants of the northern coast of Scotland, that the mermaid inhabits the neighbouring seas; and Mr. Munro, schoolmaster of Thurso, affirms, that about the year 1797 he observed a figure, like a naked female, sitting on a rock projecting into the sea, at Sandside Head, in the parish of Reay. Its head was covered with long thick light brown hair, flowing down on the shoulders. The forehead was round, the face plump, and the cheeks ruddy; the mouth and lips resembled those of a human being; and the eyes were blue. The arms, fingers, breasts, and abdomen, were as large as those of a full-grown female. This creature was apparently in the act of combing its hair with its fingers, which seemed to afford it pleasure; and it remained thus occupied during some minutes, when it dropped into the sea. The observer did not remark whether the fingers were webbed. On the whole, he infers that this was a marine animal, of which he had a distinct and satisfactory view, and that the portion seen by him bore a narrow resemblance to the human form. But for the dangerous situation it had chosen, and its appearance among the waves, he would have supposed it a woman.—Twelve years later, and not very distant from the same spot, as we conjecture, several persons observed what was supposed a mermaid. It floated at the distance of only a few yards from them, and remained in sight about an hour. Nothing except the face was at first visible; and as the sea run high, the creature sunk gently under the waves, and then re-appeared. The head was very round; the hair thick and long, of a green oil cast; and it appeared troublesome when thrown over the creature's face by the waves. As they receded, it removed its hair with both its hands, which, as well as the arms and fingers, were very long and slender. The last were not webbed. The forehead, nose, and chin, were white, and the whole side face of a bright pink colour; the throat was also white, slender, and smooth; and the smoothness of the skin, on which neither hair nor scales were observed, particularly attracted attention. The face seemed plump and round; the eyes, of a light grey colour, were small, as also the nose. The mouth was large; and, from the jaw bone, which was straight, the face was apparently short. One of the arms was frequently extended over the head of the animal, as if to frighten a bird, which, hovering about it, seemed to distress it much. When this had no effect, the creature turned round several times successively. Both here, and in the former instance, the sun shone bright, and the objects were sufficiently near the observers.

Nearly three years afterwards, in October 1811, a singular creature is said to have been seen on another part of the coast of Scotland, remote from the former. A peasant made oath in presence of a magistrate, that about four miles south of Campbeltown, his attention was attracted by a white object on a black rock. He crept through a field of corn, and then advanced among the rocks on the shore, until he approached within 12 or 15 paces of it. The upper part was white, and resembled the human form, and tapered gradually towards the tail, which terminated like a fan 12 or 14 inches broad. The under half was of a brindled or reddish grey, apparently covered with scales; but the extremity of the tail itself was of a greenish-red shining colour. Its whole length appeared to be four or five feet, and it was of the thickness of a youth. The head, hair, arms, and body down to the middle, resembled those of a human being; but as the creature lay flat on the rock, and with its head towards the sea, and was constantly stroking and washing its breast, the peasant could not discover whether or not the bosom was formed like that of a woman. The neck and arms seemed short in proportion to the body. Long light brown hair covered the head, which being sometimes raised over it by gusts of wind, the animal leaned towards one side, and with her hand on the other stroked it back, then shifting its position, adjusted it in the same manner on the opposite side. During two hours it remained thus exposed to observation; but the tide having receded, so as to leave the rock dry five feet above the surface of the water, the animal, leaning forward on one arm, then on the other, drew its body towards the edge, and tumbled clumsily into the sea. Now for the first time the face was distinctly seen, having all the appearance of the human aspect, with very hollow eyes, and the cheeks of the same colour as the rest of the face.

Still more lately it has been affirmed, that in the course of autumn, 1819, a creature appeared on the coast of Ireland, about the size of a girl of ten years of age, with a bosom as prominent as that of one of sixteen, having a profusion of long dark brown hair, and full dark eyes. The hands and arms were formed like those of man, with a slight web connecting the upper part of the fingers, which were frequently employed in throwing back and dividing the hair; and the tail appeared like that of a dolphin. This creature remained basking on the rocks during an hour, in the sight of numbers of people, until frightened by the flash of a musket, when it plunged with a scream into the sea.

These are some of the most recent narratives regarding marine animals, that had a resemblance to the human figure. But a question naturally arises, what were these animals? Had they actually some of the parts and proportions of man, or do they belong to another order, on which credulity and inaccurate observation have bestowed a false character?

We are, no doubt, very imperfectly acquainted with a multitude of animals, especially those of the aquatic tribes; and the learned Bishop of Bergen justly exclaims, "Were it possible that the sea could be drained of its waters, what incredible numbers, what infinite variety of uncommon and amazing sea monsters would exhibit themselves to our view, which are now entirely unknown." *Natural History of Norway*, vol. ii. p. 185. Many, however, have supposed, that because a narrow link appears between the human and the brute creation on land, the same should exist in the sea; and various other causes have contributed to the prevalence of this opinion. Nevertheless, the most skilful naturalists of the present age deny the existence of the mermaid: regarding those seen in the sea, as some of the various species of seals; and those exhibited as such on shore, as natural subjects disguised by art. The triton of Ælian and Pliny are different; the *woman fish* of Santos, Barchewitz, Bartholin, and Artedi, cannot be considered the same; nor can any of those animals we have described be referred to the *Musague* of the Pelew islands, sixteen feet long, and twelve in circumference, which has been lately classed with "the merman of Norway." The nature and properties of the seal are yet susceptible of many illustrations; and some have found an imperfect resemblance of the human form in certain organs, to the corresponding parts of phocæ. Parsons, *ap. Phil. Trans.* vol. xlii. p. 383. A recent voyager to the North remarks, that "these animals, in swimming, often raise themselves as far as the shoulder above the surface of the water. The first I saw in this position was at a considerable distance, and might easily have been mistaken for a man." Laing, p. 107. But the illusion may be heightened still farther; for, according to some authors, the *woman fish* of the African seas, when taken in nets by the Negroes, shrieks and cries like a woman. Captain Colnett relates also, that in the South Seas, when far from land, an animal arose beside the ship, and uttered shrieks and lamentations, so like those proceeding from a woman, as to occasion great alarm. They continued for above three hours, and seemed to increase as the ship withdrew. Captain Colnett conjectured that they came from a female seal that had lost its cub, or a cub that had lost its dam, but he declares that no resemblance could be nearer the human voice. *Voyage to the South Seas*, p. 169. The extreme rarity of what has been called the mermaid, is far from being an argument against its existence. During late years, naturalists scarcely believed in the giraffe and hippopotamus; they still debate concerning the unicorn and the mammoth; and that such a creature lived as the great sea serpent, was resolutely denied, until one was cast up by the waves on our own islands. The existence of a marine animal, partly resembling the human species, is therefore to be considered a question of evidence, which remains to be decided. (*c*)

MERSEY. See England.

MERTHYR Tydvyl, is an ill-built and irregular town of Wales, in the county of Glamorgan. It is situated on the river Tay, in the midst of bleak hills, and derives its importance from the iron forges in its neighbourhood. There is here a parish church, which is a large and handsome building, about eleven meeting-houses, a philosophical society, a printing-house, and a theatre. The iron works are on a very large scale, and strangers are much interested by the celebrated water wheel, 100 feet in diameter. No less than 250 tons of iron ore are said to be furnished weekly, and 240 tons of coal consumed daily. The articles which are here manufactured are exported by means of navigable canals to Cardiff, in vessels of 300 tons. Number of houses 240. Population 1256.

MESSINA, a city of Sicily, situated at the north-east extremity of that island, and on the eastern shore of the Straits of the same name, which are particularly celebrated from containing Scylla and Charybdis within their precincts. They are formed by a promontory of Calabria on the continental side, and Cape Pelorus on the Sicilian coast, the intermediate distance being about two miles. Scylla is a lofty rock, rising abruptly from the sea, on the shore of Calabria, 12 miles north-west of Messina: it is surmounted by a castle, and declines towards the town of Scylla on the coast. At the distance of two miles from it a murmuring noise like the confused barking of dogs is heard, which is occasioned by the dashing of the billows among the caverns below: and hence the ancients fabled a hideous female monster, surrounded by ferocious animals, ready to devour those mariners who came within her reach. In calm weather no danger is to be apprehended, but a vessel brought into the conflicting wind and the current of the Straits, which sometimes runs with great violence, is still exposed to destruction.—Charybdis, described as a raging whirlpool, which absorbed whole vessels with their crews, and then rejected the broken fragments and mangled bodies, lies 750 feet from the city. At present, when viewed from the shore, it appears like a body of water in tumultuous agitation, and on nearer approach the waves are discovered to be larger and more disturbed, dashing together, so as to produce a revolving motion among themselves, throughout a circle of about 100 feet in diameter, where the sea is 500 feet deep. The smallest barks may now cross it in safety; but when a strong wind and current are opposite, the waves become more turbulent and extensive, and three or four, or a greater number of whirlpools, are formed: Vessels driven among them are not manageable, and if unassisted by the pilots of the country, they founder, or are impelled on the opposite shore, and wrecked. Charybdis, however, is not properly a vortex; it has no power of absorption; and vessels, on the contrary, are rather repelled from it by a centrifugal force. Though extricated from Charybdis, a ship meeting an adverse wind, on leaving the Straits, may fall on Scylla, thus verifying the words of the ancients. Twenty-four pilots are kept in the service of the Sicilian government, to assist vessels navigating these Straits, which were passed for the first time by a modern fleet, it is said, when the British advanced to the battle of the Nile.

One side of the city of Messina rises from a narrow plain on the shore, along the declivity of a chain of mountains, finely wooded and diversified, and another sweeps along the margin of a beautiful harbour. It is built with considerable regularity, nearly in the figure of a parallelogram, and consists of two long principal streets, besides a third on the quay, intersected by a number of others, at right angles, all of which are paved with large blocks of lava from the volcanoes of the island. It contains several squares and open spaces, embellished with a number of statues and fountains, the latter copiously supplied from the neighbouring mountains; from whence also torrents descend through the streets, where they are confined by walls to prevent their injuring the buildings. A street called the Marina, or Palazzata, formed of a row of lofty elegant buildings, extends above a mile along the harbour, where the great depth of water admits of the largest vessels approaching to the very edge. It is penetrated by eighteen or nineteen gateways, leading to the respective streets in the city, over which are sculptured appropriate designs and inscriptions; and one end terminates with the royal palace. A considerable portion of the whole, however, as well as the statues in front of these edifices, was ruined in the year 1783, and is scarcely yet completely restored.

Messina contains numerous public edifices, among which are about fifty churches, many of fine architecture, and internally decorated with paintings, for the most part from the pencil of native masters. The cathedral, a spacious building of Gothic architecture, and highly embellished within, stands in an irregular square, where there is a bronze equestrian statue of Charles III. of Spain in the centre. Antique granite columns, brought from a temple of Neptune once standing on the Straits, support the vaulted roof and the timber work of the nave. The great altar consists of mosaic, richly executed in jasper, agate, lapis lazuli, remarkable marbles and pastes of various colours, whose combination, together with gilded bronze, produces an imposing effect. There is a marble pulpit here, the work of Gaggini, a Sicilian sculptor of the sixteenth century, which is much admired. This cathedral was erected by Roger, Count of Sicily, in the end of the eleventh, or beginning of the twelfth century; it is dedicated to the Virgin Mary, an original letter from whom, addressed from Jerusalem to their progenitors, the Messinese boast of yet possessing. Messina is an archiepiscopal see. Directly opposite to the cathedral there is a fountain, ornamented with a number of fine marble statues of nymphs and deities, alike elegant in design and execution. It is to be remarked, that some parts of the city, such as the *Square of the Four Fountains*, are named from the structures of this kind embellishing them.

Here there are not fewer than thirty convents for both sexes, which for the most part are very large, and highly ornamented with all the symbols of the Catholic faith.

The public hospital is a fine building, capable of receiving several hundred patients. It is supported by considerable revenues, arising from lands and houses, and is managed by a committee of noblemen. But, owing to prevalent abuses, there are few patients admitted, and even these are not suitably treated, both from the want of necessary attendance, and from too rigid economy. The other charitable institutions, consisting of six asylums for the poor, a house for the reception of foundlings, and two *montes di pieta*, labour under similar defects. These last are public offices under government, where money at a small per centage is advanced on goods to the necessitous, and the profits applied to support seminaries for the education of youth. Such institutions subsist in various towns of Sicily, where they are productive of the most beneficial effects, and obviate the inconvenience which is felt in other countries from the loan of money by individuals on pledges. The public prison, which by a singular deviation from a real sense of its purpose, is exhibited in a very fine structure, in one of the principal streets; it is spacious within, and superior to that of the capital in certain respects, but deficient in most of the essential requisites of such a place; cleanliness, for example, and in the sexes being separated, which are precautions alike important to health and morals. Messina also contains two houses of correction for women. The royal palace and senate-house are fine buildings.

There are four public libraries, but only two of them are of importance. The British residents in Messina, however, have established reading rooms. A newspaper, said to be the only one in the island, is published here, in Italian, called the *British Gazette*.

The state of the drama is considered very low in Messina, and the theatre in every respect unworthy of so large a population. Friday is selected for the performance of tragedy, on which evening the theatre was shut previous to the dissemination of the writings of Alfieri. From the scarcity of public amusements, gaming tables are frequently resorted to, especially by the more fashionable Sicilians.

The city is defended by two forts, Gonzago and Matagrifone; and the harbour is protected by a pentagonal fortification, called the citadel, which was erected in the year 1679. This is the strongest place in the island, and it has casemates for 5000 men. Near to it is a lazaretto, which, notwithstanding the prevalence of the plague in many parts of the Mediterranean, is the only one in Sicily; and so little regard is paid to safety, that the restrictions both on landing goods and the crews of ships under quarantine are very easily evaded.

The harbour of Messina is the best port of Sicily, containing not less than from 20 to 40 fathoms water, close to the quay, and its situation is esteemed superior to any other in the Mediterranean. Hence this city has been always a place of considerable trade. A large proportion of the produce of the island, affording no less than ninety-six articles of export, is to be found in the city. The produce of the environs is principally fruits and wines, and the chief manufacture consists of silks. What is called the Faro red wine, is in great repute with the British on account of its strength and resemblance to port, which it also equals in quality when kept three or four years. In addition to the quantity made for home consumption, about ten thousand pipes are exported yearly. The other exports are dried figs, citrons, oranges, lemons, lemon juice, manna, essence of bergamot, red tartar, goat skins, hides, mottled soap, for the American market, linen and rags, partly to England, partly to the Italian ports. Some time ago it was computed that there were exported 2000 chests of oranges, and 6000 chests of lemons, each containing 408; likewise 280 barrels of lemon juice. During several centuries silk-worms have been successfully reared in the vicinity of Messina, and their produce is to be ranked among the first sources of its opulence. There are several extensive manufactories of that article here, and many years since 1200 looms were employed in the city. The silks, however, are not highly esteemed, but by the recent introduction of the machinery constructed in Britain, their fabric throughout Sicily is in a state of progressive improvement. An ample assortment of the produce of the Levant and the Morea is brought hither by the Greeks, consisting of carpets, silks, cotton, timber, fruits, gums, drugs, and other merchandize. During later years a number of British merchants have settled here, by whom an active commerce is prosecuted, yet it is supposed with less real advantage than their original prospects contemplated. Messina is a free port, but not in the full acceptation of that term: and the inhabitants, in consequence of the misfortunes of the city, have had an immunity from taxes for 25 years.

Part of the inhabitants find occupation in the coral fishery; and in that of the sword-fish and shark during certain seasons of the year. About eighteen or twenty vessels are engaged in the first, each navigated by eight men, who are exclusively Messinese, on account of their superior personal strength and skill, and also from the dangers attending it. They obtain nearly 3000 pounds of coral yearly; but the fishermen consider this a secondary employment, and to be followed only when none more profitable occurs. In the capture of the sword-fish, from eight to twelve barks, each provided with two boats, are employed. The fishermen use either strong nets or a harpoon, which is so constructed, that, on striking the fish, the shaft is disengaged from the iron head, while both are retained by a cord 600 feet long. Much dexterity is practised here; and the fishermen, who are very superstitious, repeat a Greek sentence, as a charm to attract the fish to their barks. Most of those taken are consumed in Messina, where this fish is favourite food; and some, being salted, is sent in presents to Naples. The fishery of the shark is not regularly followed, as it resorts, at uncertain periods, to the Straits; and the occupation is attended with danger, from the great voracity of the creature.

The judicial establishments exceed all proportion to the population, which in itself produces many inconveniences; and the inhabitants are greatly dissatisfied with the discharge of the duty of their functionaries. There is a senate, consisting of fifteen members, or officers, civil and criminal courts, whose proceedings are subject to appeal in the courts at Palermo, and civil officers superintending the whole, amounting to no less than 300. It is impossible to obtain a prompt decision, which keeps a number of litigants constantly at law; and, in consequence, a great many professional persons find employment. Justice is very partially administered, which is the source of great annoyance to the parties; and the police of the city is bad. A few years ago, an Englishman having been robbed and murdered in the streets, his mercantile countrymen resident here demanded the punishment of the offenders, who, after much equivocation and delay, were convicted. Nevertheless, their relatives endeavoured to redeem them from the penalty by bribery; and it required the most vigorous efforts to obtain their execution. Forty-eight villages are dependent on the city, and governed by the same laws.

Messina is the second city in Sicily, and is at present in a high state of prosperity, notwithstanding the defects of its internal administration. The population of few cities has undergone greater fluctuation within an equal period. During its most flourishing condition, in the course of the preceding century, the inhabitants are supposed to have amounted to 100,000; successive public calamaties, however, reduced them to 25,000, or 26,000, in 1781. In the year 1798, by an actual enumeration, the population was found to amount to 45,000 souls; but so rapid has been the increase of late, that it is now computed at between 80,000 and 90,000. The cause of so unexampled an augmentation, is ascribed to the growing prosperity of the island in general, the extension of commerce, circumstances which have driven many families from agricultural pursuits, and particularly to the presence of the British forces. This is the only place in the island where there are any Jews, as that nation has been proscribed since the year 1492, when they were expelled from the Spanish dominions.

Messina is a place of great antiquity, first known by the name of *Zancle*, or *Zanclea*, from one of its founders; though some etymologists maintain that this is a Greek word, characteristic of the shape of its harbour, which resembles a sickle. A new colony having come hither from *Mycene* in Greece, it was thenceforward called *Messana*, and at a later date was the scene of sanguinary hostilities between the Romans and Carthaginians. Since that time it has participated in the general fortunes of the island. But in modern history it has been chiefly celebrated for its misfortunes. When in a very prosperous condition, the plague, introduced by a vessel from the Levant, in 1743, swept away 35,000 souls in the course of a few months; and before having completely recovered from this disaster, the inhabitants were visited by another awful calamity. At noon, on the 5th of February, 1783, a long thick cloud was seen on the opposite shore of Calabria, which was instantly followed by a hollow subterraneous rolling under the city; and, amidst a torrent of hail and rain, accompanied by loud peals of thunder, an earthquake shook it to its foundations. The inhabitants fled from their houses to the squares and open places; while a suffocating smell of sulphur escaped from the earth, opening in fissures under their feet. Incessant undulations continued during several successive hours, when at length a tremendous concussion, at about 7 or 8 o'clock of the subsequent evening, completed the overthrow of the more solid edifices, which had resisted the feeble shocks preceding it. Numbers of the citizens were overwhelmed by the ruins; many, in the scene of terror and dismay, hurried to the quay to get on board of the vessels lying there; some sought refuge in the country; but others, more intrepid, disregarded their own safety, to rescue their weaker relatives from the walls and rafters which were crashing around them. Half of the whole city was now levelled with the ground; one quarter of it rendered ruinous; and the remaining portion greatly damaged. Churches, convents, colleges, and palaces, all had fallen; the palazzata, almost through its entire length, was injured; houses, fountains, and statues were demolished; and scarcely any, excepting those structures occupying the higher grounds, were spared. To aggravate the public calamity, conflagrations succeeding the earthquake, ravaged the city during seven days; and the licentious, availing themselves of the general disorder, pillaged and murdered the defenceless without remorse. Yet amidst such a field of desolation, only 700 or 800 of the inhabitants perished, owing to the survivors having had time to quit their houses before they tumbled, and from so many having been driven to the country by their first apprehensions. Temporary huts and barracks were erected for those preserved; and the public magazines having been saved, these, along with immediate importations of provisions, alleviated their distresses. But such were their sufferings, that even with the lapse of six years they had not fully recovered from the horror and stupefaction occasioned by the disaster. A long time elapsed before the earth recovered its stability. Above 200 shocks were felt within the two months following; and the city, since that time, has been repeatedly threatened with another convulsion. At present, most of the ruins are removed, and new edifices supply the place of many that were destroyed.

During part of the late war, Messina was the head quarters of the British army, amounting, in the year 1806, to 10,000 men, sent for the protection of Sicily; and a flotilla lay in the harbour when Murat collected a force on the opposite side of the Straits. The inhabitants, nevertheless, are accused of having engaged in a conspiracy with the other islanders, to betray the British army, which was detected in the year 1812, and many of the ringleaders punished by the sentence of a military commission, composed partly of British, and partly of Sicilian officers. East Long. 15° 40′, North Lat. 38° 10′.

MESTA. See Spain.

METALLURGY, in its most extended signification, means the working of metals in every different way. It therefore includes gilding, parting, smelting, assaying, &c. in its more limited sense, however, it is used to denote the process of smelting, or the separation of metals from their ores, for the purposes of art, and the assaying of these, with the view of ascertaining their value. In this last sense it is here used.

Almost all the ores employed in metallurgy, are embedded in quartzy matter, from which they must be freed as much as possible, before they are subjected to the process of smelting. The methods followed in the reduction differ in the different ores.

The assay of ores is performed in two different ways, with the view, either of ascertaining the quantities of all the different substances which the ore contains, or only the proportion of the metal for which it is wrought. The latter of these is used in the arts, and is more properly termed assay, the former being called analysis.

When assaying an ore, for the purpose of ascertaining with tolerable precision the quantity of metal contained in a large collection of it, we must take pieces from different parts of it, and put these together, by which we procure a mixture, containing the mean quantity of metal in the different pieces. In all the different assays, the ore must be reduced to powder, or to small fragments before it is weighed, and care must be taken that none of it is thrown out of the vessel during the operation, and the product should not be removed from the crucible till it is quite cold. If the assay be well performed, the metallic button obtained, will have a convex surface, and will be of uniform density; the scoria will be compact, and without the admixture of metallic grains. We must never trust to one assay, but repeat the process several times, and, as in general there will be a slight difference in the results, we must take the mean of the whole as the quantity of metal in the ore.

In the following article, under each metal will be included the different methods practised in the smelting of its ores, and the assays which are performed on them, with the view of ascertaining the quantity of metal in them for which they are used. The metals employed in the arts, are

Iron.

For the reduction of iron ores, see Iron.

Assay. The assay of iron ores differs a little, according to the ore employed.

The common magnetic iron-stone is assayed by mixing it, when reduced to powder, with about twice its weight of a flux, composed of 1 of charcoal, 6 of chalk, and 8 of bottle glass. The mixture must be exposed to a very strong heat in a blast furnace, for about an hour, after which the iron will be found at the bottom of the crucible. If the ore contain sulphur, it must be roasted previous to its mixture with the flux.

The other ores of iron are assayed nearly in the same way. When very little earthy matter is present, they may be reduced by using charcoal without the flux; and if the ore contain much calcareous matter, the quantity of chalk in the flux may be diminished.

Gold.

Gold is always found in its native state, generally alloyed with silver and copper, and occasionally with tellurium. Some of the iron pyrites, and galena also, contain a sufficient quantity of this metal, to make them valuable as ores of gold.

When gold is found alloyed with silver mixed only with stoney matter, the method of extracting the metal is very simple. In working a mine containing gold in this state, the whole of the matter procured from the vein, is collected and broken into pieces about the size of a nut, which are arranged into heaps, according to their richness. The small fragments, and the refuse of the different processes, are also collected and arranged according to their value. The quantities thus procured, are afterwards broken into smaller pieces, and freed as much as possible from impurities. They are then reduced to powder, and made into a thick paste with salt and water. Mercury is now squeezed through a leather bag on the mixture, and as the metal flows in, in very minute globules, it is intimately blended with it by means of wooden spatules. When the requisite quantity of mercury is added, the whole is beat together, and kept at about the temperature of boiling water, for two or three days, by which the union of the gold and mercury is promoted. The earthy matter is then carried off by levigation, and the superfluous mercury removed, by squeezing the amalgam through a leather bag. What remains is subjected to distillation, by which the mercury is driven off, and the gold is obtained, perhaps containing a little silver. The method of separating these will be explained when treating of silver.

When the other ores containing gold are found in the same mine, they are carefully separated from the former, and are collected into heaps, arranged according to their richness and hardness. The process for extracting the gold from these, is much more complicated than that just described.

In extracting gold from these ores, the first part of the process consists in separating the metallic from the earthy substances. For this purpose the ore is reduced to powder, in a *stamping-mill.* The stamping-mill consists of a large cistern, in which the ore is placed, and through which a stream of water passes, and of the stampers, which are heavy beams of wood, terminated below by iron, and which are moved upwards and downwards by a water-wheel.

Great attention is necessary in this part of the process, that the whole of the foreign matter which can be removed by the hand, be separated before the ore is put into the cistern, and that the proper force be applied, according to the hardness of the ore. This is easily regulated, by increasing or diminishing the depth of the layer of ore in the cistern; hence the quantity of ore put in, is always inversely as its hardness; accordingly, when the layer of ore is thin, the stampers have a greater fall, and the ore is thus subjected to greater force. It is necessary also, that the ore be placed in a particular way. The layer is so formed, that below the two outer stampers it is thickest, and gradually diminishes towards the centre. When the ore is reduced to powder, and sufficiently fine to float in the water, it is carried off, by the stream of this fluid into vessels, in which it is deposited; the heaviest being deposited nearest the cistern. Particular care is also necessary, that the stamping be not done too rapidly, otherwise the stampers are apt to throw up pieces of the ore, not sufficiently pulverised, which flow out with the fine powder, and prove detrimental in the subsequent part of the process. The stamping should therefore be performed slowly, and the fresh ore, as it is put in, must be placed below the middle stamper, where it is subjected to the greatest force, and from which it is thrown under the other stampers.

The vessels into which the water flows from the cistern, are arranged in a particular way, and a great deal depends on the performance of this part of the process; for by altering the velocity of the current of water in them, the rapidity with which the powder is deposited also alters. The vessels are of different dimensions, that nearest the cistern being about 12 feet long, and 9 inches broad, and as many deep. The others gradually enlarge as they retire from the cistern. They also vary in their inclination, the first having a slope of about 3 inches, the second about 1 inch, the third and fourth about ½ an inch, and the fifth and sixth being level. Each vessel is furnished with a groove at the extremity farthest from the cistern, into which pieces of wood are placed, varying in height, according to the quantity of ore that is collected in the vessel, and each vessel communicates with that beyond it.

When the water flows from the cistern into the first vessel, the heavy part of the ore is deposited and collected where the wood is put into the groove; as the powder reaches the top of this, another piece is put over the former, and so on till the vessel is nearly filled. When this is the case, the water is allowed to flow into the second vessel, and from this, when full, into the third, by which means the different parts of the ore are collected, according to their specific gravity in the different vessels. The parcels of ore thus procured, are still farther freed from impurities by washing. For this purpose, each parcel is put into a wicker basket, into which a stream of water slowly flows, and which, as it issues, is received on inclined tables, grooved in various directions. By this means, the ore is still farther separated, according to the specific gravity of the particles, the heaviest being deposited in the upper groove. Some of the ores of gold are subjected to another washing, in a vessel similar in shape to a fire-shovel, called a *buddle.* This is immersed in water, and a particular motion is given to it by the workman, by which the lighter particles are thrown out, and the heavy metallic matter is left in the buddle. If the gold procured by this process be mixed only with earthy matter, it is subjected to amalgamation, as already described; or it is fused in crucibles with nitre. If, however, it be mixed with inflammable matter, as sulphur, it is roasted, by which the sulphur is expelled. It is then mixed with lime and galena, in quantity proportionate to the gold contained in it, which is ascertained by assaying it, and kept at a red heat, in a reverberatory furnace, till part of the sulphur is expelled. The heat is then increased, till the whole becomes fluid, after which it is poured into moulds of sand. The product of this operation consists of scoria above, and beneath of a metallic matter, composed of gold, silver, copper, lead, iron, and a little sulphur. By repeated fusions the gold is obtained, alloyed only with silver, copper, and lead, from which it is freed by the process of refining.

The refining of gold is performed in different ways, according to the metals with which it is mixed. Of these the most common is *cupellation*, or *testing*, the former term being employed when the operation is performed on a small, the latter, when it is practised on a large scale.

Gold is one of the metals which is not oxidated by heat and air, while the other metals, with which it is usually alloyed, except silver, pass into the state of oxide, at a high temperature. This constitutes the process of cupellation, which is merely the separation of the precious from the baser metals, by means of oxidation. When, however, the base metals are in small quantity, compared with that of the gold, the oxidation is not complete; but if a metal, which is easily oxidated, and the oxide of which is very fusible, be added to the alloy, the oxidation of the base metals is promoted, and they are completely separated. The metal always employed is lead, and the quantity added depends on the proportion of gold which the alloy contains. (For a particular account of the process of refining, see *Silver*, in this article, p. 77.)

If lead be the only metal with which the gold is alloyed, the process of cupellation is sufficient for its purification; if, however, which is usually the case, silver and copper be also present, other methods are necessary to free it from these metals. When copper only exists, the gold is mixed with silver and lead, and then subjected to cupellation, by which the base metals are removed, but the gold still retains the silver; it is necessary, therefore, to have recourse to means for separating these two metals. When the gold amounts to about one-fourth of the alloy, the process is carried on by means of nitric acid. Silver is easily acted on by nitric acid, while gold is not; if, however, the gold exceed what is stated above, the whole of the silver is not dissolved; it is necessary, therefore, for this process, that the alloy employed do not contain more than one-fourth of gold; if it do, it must be fused with poorer alloy, *i. e.* alloy which contains a great deal of silver. When in this state, it is poured into cold water, by which it is reduced to powder, or *granulated*, as it is called. The granulated alloy is then put into *parting-glasses*, which are vessels of a pear-shape, about 12 inches long, and 7 wide at the bottom. Into each of these about 40 ounces of the alloy are put along with nitric acid, so that the acid cover the alloy to about the depth of two or three inches. These are gently heated on a sand bath, and when the action has ceased, the solution is poured off, and another quantity of acid is added, and the process is repeated a third time, which is, in general, sufficient to dissolve the whole of the silver. The last portion of acid, as containing little metal, is used as the first quantity, in the next purification; the two first are decomposed by the immersion of copper plates, by which the silver is deposited in the metallic state. The gold left after the action of the acid is washed with warm water, till the fluid which comes off does not alter the colour of a piece of copper, and is then fused in a crucible with nitre and borax, by which all impurities are removed.

When the proportion of gold in an alloy is much smaller than that mentioned, a different process is sometimes followed for separating it from the silver. For this purpose, the alloy is melted and granulated. About seven-eighths of it are then mixed with about one-eighth of the flowers of sulphur, and the mixture heated in a covered crucible, first slowly, and afterwards till the whole is brought into fusion, in which state it is kept on the fire for about an hour; one-third of the alloy kept out is then added, and thoroughly stirred with it by means of a wooden rod, and the whole is again heated for about an hour. Another third of the alloy is afterwards mixed with it, and after a similar operation, the remaining quantity is added, and the mixture kept fused for about three hours, during which it is frequently stirred. It is then, when the surface has become quite white, poured into cones greased in the inside. When it is solid, it is found to have separated into distinct parts, the upper is sulphuret of silver, the lower is a metallic button, composed of gold and silver. If the former contain gold, it is exposed to heat in an open crucible, by which part of the sulphur is dissipated, and the silver set free, unites with the gold, and collects at the bottom of the vessel as the matter cools. The metal thus obtained is repeatedly subjected to the same process, till the alloy procured contain a large enough quantity of gold to admit of its separation from the silver, by the process of parting already described.

Gold is occasionally deprived of the baser metals by the use of sulphuret of antimony, sulphur having a stronger attraction for the other metals than for antimony, while it does not combine with gold. To purify gold by this means, it is necessary to employ crucibles which are not porous. To render them so, they are soaked in oil, and then besmeared in the inside with pounded borax. The gold alloy is fused in these, and about twice its weight of sulphuret of antimony is added in successive portions, taking care that the mixture does not swell and flow out of the crucible. If the quantity of gold be very small, the sulphuret must be previously fused, with an additional quantity of sulphur, so that too much antimony may not be used. When the whole of the mixture is in a state of fusion, and when it sparkles, it is poured into greased cones, which must be struck gently as the matter consolidates, to cause the gold to fall to the bottom. When cold, the gold is found united with the antimony, and also with a little of the alloying metals; it must, therefore, be subjected to the same process, with an additional quantity of sulphuret, a second and a third time, by which the whole of these are removed. The next part of the process is to separate the gold and antimony. For this purpose the alloy, reduced to fragments, is fused with one-fourth of its weight of sulphur, in a covered crucible, by which the greater part of the antimony quits the gold, and unites with the inflammable body. The fused matter is then poured into greased cones; and when cold, the gold still retaining a little antimony, is collected at the bottom. To free it from this it must be fused, and a stream of air made to pass over it, by which the antimony is oxidated, and dissipated by the heat, and the gold is left. If not quite purified by this process, it must be fused with a little nitre, which will oxidate the antimony, and leave the gold pure. The sulphuret of antimony, formed by the fusion of the alloy and sulphur, contains a small quantity of gold. To obtain this from it, it must be fused with about one fifth of its weight of iron filings, which will unite with the sulphur; the antimony will combine with the gold, and may be separated by the method above described.

The process of purifying gold by *cementation*, is still practised in some particular cases. It consists in beating the alloy to thin plates, and placing these in alternate layers, with a cement composed of 1 of nitre, 2 of calcined green vitriol, and 2 of pounded tiles, made into a paste with urine, taking care that there be cement at the top and bottom of the vessels. These are placed in a furnace, and kept at a heat, below the melting point of gold, for 24 hours. The gold is then removed, and boiled, first in water, and afterwards in nitric acid, by which the foreign matter is washed off. The plates are repeatedly subjected to a similar operation; and in this way a great deal of the alloying metals are removed by the nitric acid, set at liberty from the nitre by the action of the acid of the salt of iron on it. The superiority of this process depends on the nitric acid, at the temperature to which it is exposed, acting on silver and copper, though in small quantity, which is not the case when the liquid acid is boiled on the alloy; it does not, however, afford the gold pure, it is therefore practised only when this metal is not required very fine, as in the formation of trinkets.

Assay of Gold Ores.—As gold ores contain in general but few ingredients, their assay is easily performed. For this purpose the ore is reduced to powder, and mixed with 1 of fused borax, and 4 of sub-carbonate of potassa, and subjected to heat in a crucible. When fused, it is poured out, and if any remain in the vessel, it must be removed by muriatic acid. This, with the fused matter reduced to powder, is digested in muriatic acid, to which from time to time a little nitric acid is added. When the action ceases, the solution is poured off, and the residue is well washed with water, the washings being mixed with the solution. To the solution, neutralized by a fixed alkali, green sulphate of iron is added, as long as it causes any precipitation; the precipitate, after being washed, is fused in a crucible with a little nitre; and affords gold in a state of purity. If the part of the ore not acted on by the acid become black by exposure to light, it contains silver. To procure this, it must be fused with about thrice its weight of sub-carbonate of potassa, by which the silver is reduced and is mixed with the earthy matter. By washing the product in muriatic acid, the latter is separated, and the silver is left.

Iron pyrites containing gold is analysed by digesting the ore in muriatic acid, to which a little nitric acid is added. What is left must be roasted to drive off the sulphur, and again digested in acid. The solutions obtained must be neutralized by potassa, and proto-nitrate of mercury is added. The precipitate thrown down is then fused with nitre, by which the gold is procured. If silver be also contained in the ore, it is obtained by treating that part of it not acted on by the acid with sub-carbonate of potassa and muriatic acid, as above described. Galena, containing gold, is analysed by digesting it in nitro-muriatic acid, evaporating the solution, and afterwards adding proto-nitrate of mercury. The insoluble part, when treated as above, will yield the silver, if any exist in the ore.

The assay of gold, as performed on its alloys, will be given when treating of assay of silver.

Silver.

Silver is obtained not only from the proper ores of silver, but likewise from some of the ores which are wrought to yield other metals. Of these the principal are the ores of lead.

Reduction of Ores.

Two methods are practised for procuring silver, the one is by *amalgamation*, the other is by *fusion*. The former is followed when the ore is rich in silver, the latter when it contains little of the precious metal.

Amalgamation. The ores which are subjected to the process of amalgamation contain, in general, besides lead and copper, a small quantity of iron pyrites; if they do not, some of this is usually mixed with them, by which the extraction of the silver is facilitated. The ore, after being freed as much as possible from its stony ingredients, is mixed with common salt, in the proportion of 8 or 9 per cent. if the ore contain 8 oz. per quintal; and 10 or 12 per cent. if more silver be contained in it. It is then exposed for some hours on the floor of a reverberatory, till the vapour cease to come off; the mixture being frequently stirred to expose the whole of it to the flame. If, when removed, too little or too much of the salt have been added, (which the workman by experience easily knows,) the proportions must be adjusted, by adding either more of the salt or of the ore, and the mixture is again roasted in the reverberatory. During this part of the operation, the sulphur of the ore is partly dissipated in the form of sulphurous acid, part of it in the state of acid combines with the alkali of the salt, and the muriatic acid set free unites with the silver. When the matter is cold, it is reduced to powder in a mill, and then amalgamated with about an equal quantity of mercury. The amalgamation is performed in barrels, which are made to revolve, or in tubs which contain an apparatus for keeping the mixture in constant agitation. The mixture is put into these vessels, and made into a thickish paste with water, and kept agitated for about two days, and after the amalgam has fallen to the bottom, it is withdrawn through an aperture in the lower part of the vessel. What remains is washed, by which more of the amalgam is got from it, and the residual matter, if the ore contained a great deal of silver, is again roasted with about 3 per cent. of sulphur, and subjected to a similar process, by which the whole of the metal is extracted. The amalgam procured by these different operations is freed of its superfluous mercury, and is then subjected to distillation, by which the whole of the mercury is expelled and the silver is left; retaining, however, a little copper, which is removed by cupellation.

Fusion.—The ore generally subjected to the process of fusion is lead glance, which almost always contains a small quantity of silver. When lead mines are wrought on account not only of the lead, but also of the silver, the earthy matter mixed with the ore is considerable, and the quantity of silver is very various in different mines. In some, as those formerly wrought in Yorkshire, the silver amounted to about 230 oz. in the ton, while the Durham and Westmoreland mines afford only 17 oz. per ton.

The first part of the process for procuring silver from these ores consists in stamping and washing, as has been already described, after which the substance contains silver, lead, iron pyrites, blende, and earthy matter. The ore is then roasted in a reverberatory to drive off the sulphur, taking care that the heat be not so high as to fuse it, and that when it begins to adhere together on the surface, it be well stirred. In about five or six hours, the flame from the ore changes from blue to white, charcoal in powder is then thrown in, by which part of the lead ore is reduced, and collects at the bottom; when a sufficient quantity is formed, quicksilver is mixed with the scoria to thicken it, and the fused metal is drawn off. After this, the heat is continued, and the metal, as it is formed, is repeatedly taken out, the temperature being increased towards the end of the process, to cause the scoria to become more liquid, so as to allow the metal to fall through it. The metal, as it is collected, is covered with charcoal; and the scoria which is formed is removed. It is then covered with saw-dust, pieces of wood, and a little resin, and constantly stirred; and when the flame ceases, it is poured into moulds. The scoria procured in the different operations is afterwards heated in a blast furnace, to procure the lead from it.

The lead containing the silver obtained by the above operations, is then subjected to the process of refining, which is the same as cupellation, only performed on a large scale. For this purpose, a reverberatory furnace is employed, but the process differs in different places, owing to a difference in the nature of the ore. In England, the cupel, or vessel in which the refining is performed, is composed of 6 parts of bone ashes, and 1 of fern ashes, made into a paste with water. In the centre of this there is a shallow cavity, for the reception of the metal, and at one end there is a hole for the escape of the litharge formed during the operation; the litharge flowing into this, along a groove made in the cupel. When the cupel is heated, the metal is put in through an aperture in the furnace, and a stream of air is made to play on it, by which the litharge is formed, and escapes along the groove. As this groove is destroyed, the litharge is made to run along another, and in this way the whole of it is withdrawn. The metal in the cupel is again subjected to a similar operation, after which it is poured into moulds, and formed into ingots.

In other places, the lower part of the reverberatory is covered with wood ashes and clay, so as to form a cupel. On one side of the furnace there is a hole for the exit of the litharge; and on the opposite side is another for the admission of air to the surface of the metal, which is introduced through an aperture above, to which a cover is adapted. After the lead is melted and brought to a red heat, the blast of air is admitted, and the scoria as it collects is removed. When the litharge is formed, the heat is increased, and the quantity becomes greater, and is withdrawn through the opening in the furnace. At the same time some lead is volatilized. Towards the end of the process, the litharge which comes off contains a small quantity of silver, and is therefore kept separate from the rest. After the whole of the litharge is removed, and the surface of the metal in the furnace becomes bright, a quantity of water is poured on it, to prevent the metal from spirting, which it is apt to do when congealing. The metal thus obtained, is subjected to a similar operation for about five hours, in a smaller furnace, and at a higher temperature, by which it is freed from the lead.

Silver is also occasionally procured from the silver ores by the process of fusion. The process, as carried on in France, consists in mixing the ore (which contains native silver, sulphuret of silver, iron pyrites, arsenic and cobalt,) with lime, the scoria of a former operation, and slag from an iron furnace, to make it more fusible. Galena and litharge of a previous process are also added. These, when mixed, are exposed to heat in a blast furnace, along with charcoal, by which a metallic matter, composed of silver and lead, is obtained. This is again fused with litharge, and the metal procured is afterwards subjected to the process of cupellation, at a temperature higher than that in the other instances, owing perhaps to the presence of iron, which occasions a considerable loss of silver.

When the ore also contains copper, a different process is followed for procuring silver from it. The ore is mixed with another ore, containing silver, iron, and sulphur, and with the scoria of a former process. The mixture is fused in a blast furnace, and the sulphur unites with the silver, with the lead, and with the copper. The matter, during cooling, separates into two parts; that below, amounting to about one-fourth, is the silver mixed with lead, copper, iron, sulphur, and arsenic, and is roasted to expel the two last ingredients, and to oxidate the iron. It is then mixed with about one and a half of rich ore, and some scoria, and is fused. The metallic matter thus obtained is again roasted, and fused with about one-half of litharge, and as much scoria. When cold it separates into three parts, 1st, lead mixed with silver; 2d, copper and silver; 3d, scoria, also containing copper. The second of these is melted with lead and copper scoria, and afterwards with litharge and scoria, by which the silver unites with the lead. Should the whole of the copper not be removed, the metal must be repeatedly fused; by which not only the copper, but the other impurities are, separated. The scoria of this process is kept and mixed with ore in other operations.

Eliquation.—Silver is also sometimes separated from copper by the process of eliquation. The eliquation of silver ore is performed by melting the alloy of copper and silver mixed with lead, or with litharge and charcoal. For this purpose a blast furnace is employed, having its bottom lined with charcoal, beat together, and forming an inclined plane. When the furnace is kindled, it is filled with charcoal, to which some scoria is added, which, by the heat, is fused, and adheres to the sides of the furnace. A quantity of lead and of the alloy is then thrown in, and afterwards litharge mixed with charcoal. Another quantity of the alloy and litharge is then added, and lastly some lead. By the application of a strong heat, these substances are fused, and the litharge is reduced by the charcoal; the melted matter collects at the bottom, and is drawn off into moulds lined with clay, and previously heated. While the metal in these is in a state of fusion, a bar of iron bent at the end is plunged a little way into it, by which it is removed, when cold, from the mould.

The loaves are then placed in a furnace, on bars of iron, and separated from each other by bricks. By the application of heat, the lead is melted, and runs along a groove in the lower part of the furnace, carrying with it the silver. In this part of the process, great care must be taken not to raise the heat too high, otherwise part of the copper will be melted, and run out with the lead. When the lead ceases to flow from the loaves, the fire must be stopped, after which the copper is left in the state of a reddish spongy mass, still retaining a minute quantity of silver, perhaps not exceeding half an ounce in the 100 pounds; they are therefore exposed to heat, by which a metallic matter exudes from them, consisting of silver, lead, litharge, arsenic, and scoria, and if the heat has not been cautiously applied, of some copper. When the metal which exudes has a reddish colour, the process must be stopped. The metal procured by this operation is freed of some of its impurities by washing, and is then subjected to cupellation. The copper left in the furnace is nearly pure.

In the first part of this process, the heat must be less than what is necessary to melt the copper; and by using litharge and charcoal instead of lead, the operation is expedited, because the litharge, before it is reduced, proves a good flux. If lead be employed, it should amount, at least, to two and a half times the quantity of copper, otherwise the whole of the silver will not be extracted. On the contrary, it should not exceed four times the quantity of copper, otherwise part of that metal will be carried along with it and the silver; the proper proportions therefore are between three and four parts; the exact quantity will of course depend on that of the silver. It is necessary also, that the ore contain a certain quantity of silver, otherwise the process is not complete. From one to three-fourths per cent. seem the best Should, therefore, the different ores have different quantities of this metal, they must be mixed, so as to get a collection which contains the proper proportion of it.

In Germany, where the copper alloy contains about three-fourths per cent. of silver, the proportions of the substances employed, are three of the alloy, and eleven of lead. When the alloy does not contain so much silver, about ten of lead are used. If, instead of lead, litharge be employed, 120 of the latter must be used for each 100 of the former that were requisite.

Assay.—The word assay, in its extended sense, means the analysis of the different metallic ores, with the view of ascertaining the quantity of valuable materials which they contain; in its more limited acceptation, however, and in which sense it is usually employed, it signifies the process followed for ascertaining the quantity of gold and silver, either in an ore, or in alloys of these metals. In a still more limited sense, it applies only to the analysis of the latter, as in determining the quantity of gold or silver in plate, coins, and articles of jewellery. The assay of gold and silver alloys requires to be performed with very great care, as it is done on a very small scale. Before a piece of plate can be stamped, it must be assayed. For this purpose, before it is finished, it is taken to the assay-master, a person in the pay of the Company of Goldsmiths, who scrapes off a small quantity of it at different places; these he collects together, and sets aside for the assay. The same is practised with the other alloys submitted to his examination.

When treating of gold, it was mentioned that it and silver resist the action of heat and air, while the other metals with which they are alloyed, are oxidated at a high temperature. On this depends the assay of gold and silver alloys. For the complete success of this process, it is necessary that the quantity of base metal be large, otherwise the attraction between the noble metal and it prevents their separation. For this reason, a quantity of lead is always mixed with the alloy. The separation of gold and silver from other metals, by means of lead, is called *cupellation*, and the process is performed on a *cupel* placed in a *muffle*. A cupel is a dish of a circular or pyramidal shape, made of bone-ashes, and having a small depression on its upper surface, into which the alloy is put. A muffle is a vessel made of earthen ware, flat below, and arched above, open at one end, and shut at the other, and at the sides, except where it is perforated by small holes. The furnace employed in cupellation is one in which a strong heat can be excited, and having a hole in its sides for the admissinn of the muffle. When the cupellation is to be performed, the muffle is placed in the furnace, to which it is generally secured by luting The furnace is then kindled, and the muffle and cupels are slowly heated. When these are red-hot, the alloy, beat out to a thin plate, and rolled up in a sheet of lead, obtained by the reduction of litharge, is put into the cupel. To prevent the air which enters the muffle from lowering the temperature of the metal, a quantity of burning charcoal is put at its mouth, by which the air, previous to its entrance, is heated. After the metal is put in, it very soon melts, and emits white fumes, and a quantity of a reddish substance is formed, which is absorbed by the cupel. This is the lead oxidated, carrying along with it the metal with which the silver is alloyed. As the process proceeds, the fused metal acquires a globular form, and its surface is studded over with melted litharge; at last the silver acquires a beautiful brilliancy, which is a proof that the cupellation is finished. The cupel is then allowed to cool slowly, to prevent the contraction of the outer parts of the metal from scattering about the internal unconsolidated portion. The silver is then taken out and carefully weighed.

It is of material consequence to know the exact quantity of lead that must be added to the alloy, for, if too little be used, the whole of the base metals are not extracted, which is known by the metal left in the cupel being flat, of a dull colour, and adhering to the dish. If too much lead be employed, the litharge formed carries along with it a minute quantity of the noble metal; accordingly, if the litharge be again subjected to cupellation, it leaves a little silver on the cupel. To ascertain the quantity of lead requisite, *touch-needles* were formerly employed. These were bars of alloys, containing different known quantities of silver and copper, with which the alloy to be assayed was compared. This mode is however almost abandoned, the assay-master trusting to the appearance of the alloy, the ease with which it is cut, its malleability, and the colour of its surface, when heated. It is of very great importance also to attend to the heat required. If the heat be too strong, part of the silver is volatilized; if too low, the litharge is not absorbed by the cupel.

If the process of cupellation be well performed, the button of metal left adheres slightly to the cupel, its surface is brilliant, and quite clean, and it has a globular shape The silver also sometimes presents a laminated structure, which, when viewed through a microscope, appears composed of scales of a pentagonal shape. This is a good test of the purity of the metal; for when any of the alloying metal is left, the surface is quite smooth. Where great delicacy is required in the assay, two portions ought to be subjected to cupellation at the same time; and should the results not agree, the operation must be repeated.

The assay of silver ores, with the view of ascertaining the quantity of silver, is performed nearly in the same way as the assay of the alloy. For this purpose the ore is roasted, and then mixed with litharge, and quickly fused. The product is then fused with black flux, by which the litharge is reduced, and the lead falls to the bottom, carrying with it the other metals. The metallic button is afterwards mixed with the proper quantity of lead, and subjected to cupellation, by which the silver is obtained pure. Should the ore contain gold, this will be found along with the silver. These must therefore be separated by the process of *parting*, described under the assay of gold.

The analysis of the ores of silver, with the view of ascertaining the quantity of all the ingredients, is performed chiefly by the action of nitric acid. That just described is, however, the one usually followed in the arts.

Assay of Gold Alloys.—The affinity between gold and silver is so strong that they cannot be separated entirely from each other by cupellation, unless a quantity of silver be added; besides, gold is frequently alloyed with copper and silver, or with silver alone, as in some coins and trinkets. This makes the assay of gold more complicated than that of silver, as the gold and silver must also be separated from each other. In general, the silver added to the alloy amounts to about three times the quantity of gold, though some recommend that only twice the quantity should be employed.

The alloy being mixed with the requisite proportions of lead and silver, is placed in a muffle, and the cupellation is performed in the same way as with silver. When the process is finished, the button of metal is taken out, and kept in a state of fusion in a crucible, for some time, by which the whole of the lead is expelled. It is, when cold, beat into a plate, again made red hot, and slowly cooled. It is afterwards extended into a thin leaf, between steel rollers, and coiled loosely up, in which state it is submitted to the process of *parting*, by which the gold and silver are separated.

In the cupellation of gold, the heat required is stronger than is requisite for that of silver; and there is little risk of making it too high, as the alloy of gold and silver is not volatilized.

As in the cupellation of silver, it is necessary that the due proportion of the metals with which the alloy is to be mixed, be employed. This is ascertained in different ways. A tolerably accurate idea of the quantity of gold in an alloy is acquired by the use of *touch-needles.* Of these there are four different kinds: 1*st*, gold alloyed with silver; 2*d*, gold and copper; 3*d*, gold, with two of silver and one of copper; 4*th*, gold, with two of copper and one of silver. These have different quantities of gold alloyed with them; they are not, however, much employed, more particularly those containing copper, as the colour communicated by this metal to gold does not differ much from that of the different kinds of copper.

Another method by which the quantity of gold is estimated, is by the streak which the alloy gives on the darker sorts of basalt, or on black pottery. The streak is compared with those given by touch needles, which is, in general, made more distinct by the stone being previously wetted. Occasionally a drop of nitric acid is put on the streak, and by the effects produced on it the quantity of gold is estimated. By the different colours communicated, the workman acquires, by experience, an idea of the quantity of gold present. When the proportion of gold is large, it is necessary to add a little muriatic acid to the nitric acid, otherwise the streak is not affected; the gold seemingly protecting the other metals from the action of the acid. According to Vauquelin, the best acid is composed of 98 nitric acid, of specific gravity 1340, 2 of muriatic acid 1173, and 25 of water. When this acid is used, it must not remain long on the streak.

The quantity of lead added to the alloys of silver and gold is differently stated by different assayers. According to the experiments of Tillet, Hellot, and Macquer,

1 copper,	3 silver, require	40 of lead.
1	5	48
1	23	96

The quantity of lead necessary increasing with the silver. Others recommend a smaller quantity of lead. The proportion of lead added to gold alloys is nearly the same.

After the cupellation, the product must be subjected to the process of parting, which is nearly the same as has been described, when explaining the methods practised in the purification of gold. For this purpose, the coil of metal is put into a pear-shaped glass vessel, with two or three times its weight of slightly diluted nitric acid, and heat is applied, by which the acid acts on the silver, and leaves the gold. When the action has ceased, which is known by the cessation of the red fumes, the coil is left corroded, but unbroken; the fluid is then poured off, another quantity of acid is boiled on it for a few minutes, and again decanted off; the vessel is then filled with water, and inverted, by which the coil falls out entire. The metal is afterwards subjected to a high temperature, by which it shrinks, and at last forms a button of resplendent gold; after which it is accurately weighed. The silver in solution is obtained by the immersion of a piece of copper, or by the addition of common salt, and fusion with pearl ashes.

It is of great consequence to be able, by easy methods, to separate gold from metals with which it is alloyed, when these are in large proportion, as in gold lace, and in gilded goods.

In separating gold from gold lace, the metal is fused and granulated, by pouring it into cold water. It is then treated nearly in the same way as has been explained for separating gold and silver, when the former is in small proportion.

For this purpose, a quantity of the granulated metal is mixed with one-eighth of flowers of sulphur, and kept in a state of fusion for about an hour, or till a kind of flashing appears on its surface. A quantity of the granulated metal, equal to about one-sixteenth part of the weight of that fused with the sulphur, is mixed with one-half its weight of litharge, and one-eighth of sandiver. The one-half of this is then added in successive portions to the fused mixture, which is well stirred on each addition. After this is added, the mixture is kept in the fused state for about ten minutes, and the upper part of it, which is silver in union with sulphur, is removed; the remainder is then poured into greased cones.

The portion removed is brought to a state of fusion, and the remaining half of the mixture of alloy, litharge and sandiver, is added in the same way as above described, and the product is poured into a cone.

At the bottom of the cones a metallic matter, composed of silver, with almost the whole of the gold, is collected. The substance above this still, however, retains a little gold; it is therefore again fused, and a small quantity of an alloy of equal parts of copper and lead is mixed with it, by which the whole of the gold is separated, or collected at the bottom of the cone into which the mixture is poured.

The different portions of metal procured are mixed and fused with one-eighth of lead, and treated in the same way as before, with sulphur, the mixture of alloy, litharge, and sandiver. What is collected is then fused with one-sixteenth part of sulphur, and kept in that state for half an hour. It is then poured into the cone, the silver and sulphur collect at the top, and the gold falls to the bottom. The sulphuret of silver must again and again be fused with sulphur, till the whole of the gold is separated. The gold collected is then fused with one-sixteenth of copper and granulated; the same quantity of sulphur is now mixed with it, and the mixture is fused for about a quarter of an hour, and then poured into a cone. The gold found at the bottom of this, is afterwards purified by sulphur and antimony, as already described.

In gilded copper goods the quantity of gold is very trifling, still, however, it is of consequence to separate it from the other metals; this is done in two ways: 1st, The gilded metal is fused and granulated, after which it is again fused, and flowers of sulphur are gradually added, till the whole becomes dark-coloured. When cold, it is reduced to powder, and amalgamated, as already described when treating of the ores of gold.—By this means the mercury combines with the gold, and leaves sulphuret of copper.

2*d*. The metal is brought to a state of fusion, and about an equal quantity of a mixture of litharge and sulphur, previously fused together, is added to it, and the whole is well stirred. Charcoal in fine powder is then thrown in, in small portions at a time, the mixture being constantly stirred with a copper rod. By this means the litharge is deprived of its oxygen, and the lead falls to the bottom, carrying the gold along with it.

The alloy of these metals is then subjected to the process of cupellation, by which the gold is obtained pure.

The quantity of silver on plated copper goods is often so great, as to make it an object of considerable importance to be able to separate this metal from the copper.

The process for separating silver and copper, when the former is in large quantity, has been already explained, but the proportion of the latter metal in plated goods is so great, that the silver cannot by these means be obtained from them, because they will not bear to be alloyed with a sufficient quantity of lead; recourse must therefore be had to other methods.

The best mode of separating copper and silver in plated goods was recommended by Mr. Keir. This gentleman discovered, that an acid composed of sulphuric and nitric acids did not act on copper, while it dissolved silver; he therefore applied this to the separation of these metals. For this purpose, 1 lb. of nitre is dissolved in 8 lb. or 10 lb. of sulphuric acid, with the aid of a gentle heat, in a glazed earthenware dish. Pieces of the goods are then thrown in, and the heat is raised to about the 200dth degree. When the whole of the silver is dissolved, the fluid is poured off, and the metal is precipitated by muriate of soda, and is obtained in the usual way; or the solution is diluted with water, and pieces of copper are immersed in it, by which the silver is precipitated in the metallic form, the diluted acid acting on the copper.

There is still another method of separating silver from copper, by means of the black oxide of manganese, when the silver is in large proportion.

The process consists in subjecting thin pieces of the alloy, surrounded by black oxide of manganese, to an intense heat, by which the metal is melted, and a black powder is procured. This is mixed with three times its bulk of pounded green glass, and again exposed to a strong heat, after which the silver is obtained pure at the bottom of the vessel. In the first part of this process the silver and copper are oxidated, and in the latter, the oxide of silver is reduced by heat alone, whereas the oxide of copper requires the presence of inflammable matter for its reduction.

Platinum.

Owing to the infusibility of Platinum, it is with great difficulty obtained in mass, so as to have it in a state fit to be wrought into different articles. The simplest and the cheapest method of working Platinum, is that practised in France. For this purpose, the grains of Platinum are mixed with an equal weight of white arsenic, and one-third of pearl-ashes. This is thrown, in successive portions, into a red-hot crucible, and well stirred with a platinum rod. When the whole is in a state of fusion, the crucible is removed from the furnace, and the mixture is allowed to cool. It is then taken from the pot, and bruised, and again subjected to a similar process. If after the second fusion the metallic matter is magnetic, it must be a third time treated in the same way.

After this it is mixed with an equal weight of white arsenic and a small quantity of pearl-ashes, and again fused in a flat earthern dish, in which it is allowed to cool.

It is next exposed to a heat in a muffle, sufficient to expel the arsenic, but not so high as to fuse the mixture. It is then, when hot, plunged into oil, and the exposure to heat and immersion in oil repeated, till the whole of the arsenic is driven off; the heat being gradually increased as the metal becomes less fusible. After the arsenic is expelled as completely as can be effected in this way, and the charcoal of the oil is consumed, it is digested in nitric acid, and then boiled in water to remove impurities. Several of the pieces of metal thus obtained are put together, and then exposed to a high temperature; in which state they are struck so as to make them adhere. The mass is then heated in a forge and beat on an anvil, by which one compact piece of metal is procured.

Platinum obtained by the above process is not pure; it contains arsenic, and the foreign ingredients of the grains, by which it is not so capable of standing an intense heat, or of resisting the action of chemical agents.

The other methods of obtaining platinum is by reducing its oxide obtained by dissolving the grains in nitro-muriatic acid, and precipitating by muriate of ammonia. For doing this, different processes are followed, though they all nearly agree with each other.

The best of these is, perhaps, that recommended by Mr. Cook.

It consists in exposing the precipitated oxide to heat, by which it is reduced, and the superfluous muriate of ammonia is expelled. About half an ounce of the spongy mass obtained is then put into an iron mould, and squeezed together by a wooden pestil. After this another half ounce is added, and in this way the operation is continued, till about six ounces are squeezed into the mould, which are still farther compressed by a strong iron screw, by which the whole of the air is expelled. It is then laid on burning charcoal, and exposed to a high temperature, and when hot beat on an anvil till it is of uniform density. After this operation, it is coated with a reddish crust, which is removed by covering it with borax and exposing it to a white heat; it is then washed with muriatic acid, which dissolves the foreign matter, and leaves the metal resplendent.

Platinum thus obtained still retains Iridium, which was precipitated from the nitro-muriatic solution; it is however sufficiently pure for the manufacture of utensils.

Before subjecting Platinum to any of these processes, the grains must be spread on a table, and a current of air from a bellows must be passed obliquely over them. By this the lighter particles, which consist of quartz and iron ore, are removed.

Occasionally the grains, as brought to Europe, contain a minute portion of gold. This may be got from them by treating them with a small quantity of nitro-muriatic acid. To the solution green sulphate of iron must be added, and the precipitate thrown down, purified by fusion with nitre and borax.

Copper.

The ores of copper generally employed for yielding the metal, are the sulphurets. These are wrought principally in Cornwall, in Anglesea, and in Hungary.

In Cornwall, the ores of copper are broken into small pieces, which are roasted in a furnace, somewhat similar to a reverberatory furnace, having a very long chimney to increase the heat, and to carry off the sulphur and arsenic with which the ore is roasted. During the roasting, which continues for about twelve hours, the ore is frequently stirred, so as to expose the whole of it to the flame. It is then put into a small furnace of the same form, and brought to a state of fusion, occasionally mixed with a little lime, to increase the fusibility. As the impurities collect at the top, they are raked out, and put into oblong moulds, in which they are allowed to cool. They then form a hard mass, which is used in building. The fused copper is drawn out through a hole in the lower part of the furnace, which was stopped by clay, mixed with a little coal, to prevent it from hardening. Fresh quantities of the roasted ore are then put in, and the process is in this way carried on for a considerable time.

The fused copper is conveyed into vessels suspended in a well, through which a stream of water runs. By this means the metal is reduced to the granular state. It is still, however, impure, being mixed with sulphur and arsenic.

To free it from these, the metal is repeatedly subjected to heat in a reverberatory furnace, and each time put into the well. During these processes, the slag collects on the surface of the fused metal; but as this contains a considerable quantity of copper, it is kept and mixed with the fresh ore, previous to its being put into the furnace.

The copper after this is kept at a low red heat for two days, and is then repeatedly fused, and cast into moulds about 14 inches in length. It is lastly put into the refining furnace, with a little charcoal, in which it is again fused. If after this it bear the hammer, it is fit for sale. When the fused copper is cast into the moulds, the purest part of it rises to the top, and may, when cold, be easily separated from the rest, by a blow of a hammer.

The copper ores of Anglesea are wrought nearly in the same way. The ore there, after being reduced to fragments, is put into a kiln, the flues of which terminate in a close chamber. Heat is then applied to the ore, and the sulphur, which sublimes, is carried through the flue, and condenses in the chamber. Fresh quantities of the ore are from time to time introduced, and the roasting is in this way kept up for several months.

The poorer part of the ore only is smelted in Anglesea, the richer portion being exported.

The smelting of the ore is carried on in a series of reverberatory furnaces, having tall flues to increase the draught. In these the ore mixed with a little coal-dust is fused, and purified by repeated fusions. By this means, twelve hundred weight of the roasted ore yield about one-fourth of a hundred weight of malleable metal; and each charge of the furnace, which is about twelve hundred weight, is finished in five hours.

In Hungary, the copper ore is treated in the same way, but the purification of the metal is accomplished by means of lead. For this purpose the metal is fused in a furnace, and about one-twelfth or one-fifteenth of lead is added, which forms a scoria along with the impurities of the copper. This is removed as it is formed, and the copper is left in its pure state, after which it is kept fused for some time. To ascertain when the whole of the impurities of the copper have been removed, the workman takes out a little of the melted metal on the end of a smooth iron rod. If the metal be pure, this falls off when it is dipt into cold water.

The purity of the metal is also known by the redness of the scoria, that of the impure copper being always dark coloured.

The thin sheets of copper used in the arts, are prepared when the metal is in a state of fusion in the furnace. For this purpose, when the whole of the impurities have been removed, the metal is allowed to cool to near its point of congelation. A wet broom is then drawn along its surface, by which means a thin layer of it is made to pass into the solid state. This is removed, and immediately plunged into water, by which it acquires a fine red colour; and the process is repeated till the whole is formed into thin sheets.

Copper, in a state of considerable purity, is sometimes procured from the springs which contain the sulphate of this metal. With this view, pieces of iron are put into the water, by which the copper is precipitated, owing to the superior affinity of the iron for the acid, aided, perhaps, by a galvanic action. When the whole of the iron is dissolved, the matter deposited is raked out, and is fused in a furnace, either alone or mixed with some of the poorer copper ore.

The deposit obtained in this way, when fused alone, commonly yields about 50 per cent. of copper.

Assay of Copper Ores.—The assay of copper ores may be made either in the dry or in the humid way; the former, however, when the sulphurets are employed, is imperfect; but when any of the oxides or carbonates are to be assayed, this method answers very well. The ore, after being reduced to powder, is mixed with charcoal, and exposed to a strong heat in a crucible, removing the scoria as it is formed. As the ore contains other metals besides copper, this process must be repeated several times before we obtain it pure. These ores are, however, seldom employed in metallurgy; it is necessary, therefore, to have recourse to other means, to ascertain the value of those which are used to yield copper. For this, the ore must be digested in muriatic acid, to which a little nitric acid is added, by which we obtain the different metals in solution. From this the copper may be procured, either oxidated or in the metallic form, the other metals in the solution being previously separated. Lead, if present, may be thrown down by sulphate of soda and iron, by the addition of ammonia in excess.

The quantity of copper may then be ascertained, either by precipitating it by sub-carbonate of soda, or, which is better, by the immersion of a plate of iron. For this purpose the solution is diluted with water, and a piece of polished iron is put into it, which soon becomes covered with a coating of copper, and as the decomposition proceeds, the metal is deposited in thin plates. When the whole of it is separated, it is collected, washed, and weighed. Towards the end of the process, the fluid should be heated, which favours the separation of the copper.

For obtaining the copper in this way, it is necessary that we have the metal dissolved in muriatic or sulphuric acid, for the nitrate of iron generated by the decomposition of the nitric acid solution is itself liable to be decomposed by heat. If, therefore, the copper be dissolved in nitric acid, the solution must be evaporated to dryness, and the residue, dissolved in muriatic acid, again evaporated and dissolved in water; or the metallic ingredients of the nitric acid solution may be precipitated by potassa, and the precipitate dissolved in muriatic acid. Into either of these solutions, the plate of iron is immersed. Zinc is sometimes employed to precipitate copper, but as this separates iron also if present, it is liable to fallacy. Even if the solution do not contain iron, yet if there be an excess of acid, and the zinc itself contain that metal, it will first be dissolved by the acid, and then precipitated by the zinc; for this reason its use is improper. Occasionally the precipitated copper, before it is weighed, is mixed with oil and borax, and subjected to heat in a crucible, by which it is freed from impurities, and the metal is thus obtained in its pure state.

Assay of Copper Alloys. Perhaps there is no metal, the alloys of which are more numerous and more useful than those of copper. It is of consequence, therefore, to be able by analysis to ascertain the proportions of the ingredients which they contain. It must be remarked, however, that though, by the aid of chemistry, we can ascertain with precision, not only the ingredients, but the proportions of the substances contained in these alloys, yet we often fail in forming an alloy possessed of all the properties of that subjected to analysis. This depends, in a great measuse, on the difference in the purity of the metals which we employ; a slight difference in these causing an alteration in the properties of the alloys which they form. The assay of these ores is also useful, as it enables us to procure from them the metals in their separate state. This is chiefly practised with the view of obtaining the copper.

The most important of the alloys of copper are those with tin. Tin, when added to copper, renders it harder, more sonorous, and more fusible: hence it is employed in the formation of bell-metal, and the other useful alloys of copper. When copper is alloyed with tin in the proportion of 100 of the former to about 8 or 12 of the latter, it forms the metal employed in the manufacture of ordnance. Bronze, and bell-metal, are composed of about 100 copper and from 10 to 20 of tin, to which occasionally a little zinc, and sometimes also antimony is added.

When the tin is in larger proportion, as about 30 of copper to about 15 of tin, the alloy is speculum metal, which is very hard, and admits of a fine polish. With this, a little zinc, silver, and arsenic, are mixed.

When the alloy consists only of copper and tin, we have an easy way of separating these metals. Tin not only is more easily oxidated by heat and air than copper, but the protoxide of the former metal has the property of depriving the protoxide of the latter of its oxygen, by which it is reduced. We have only therefore to subject the alloy to heat to obtain the copper in its metallic form. In this process we do not procure the whole of the copper existing in the alloy; besides, if we apply the heat by which the metals are oxidated too long, the tin attracts more oxygen from the air, and does not thus deprive the protoxide of copper of its oxygen. Thus Fourcroy found, that when he exposed an alloy of 80 of copper and 20 of tin to heat and air, till they amounted to 104, 54 parts of copper were obtained by afterwards subjecting the whole in a covered vessel to a high temperature. When, however, 100 parts of the same alloy were heated with access of air till they increased to 117, a very minute quantity of copper was obtained from them by the subsequent heating. According to Fourcroy, when copper is to be obtained by the method just mentioned, the alloy, supposing it composed of 80 copper and 20 tin, should be heated in the air till it gain about 6 or 7 parts in weight, and then subjected to a high temperature in close vessels. When the alloy has been too much oxidated, it must be mixed with the due proportion of alloy, and then exposed to a high temperature, by which a large quantity of metallic copper will be procured.

Occasionally a little nitre, or black oxide of manganese, is mixed with the alloy, by which the oxidation is more speedily accomplished. Some glass or salt should also be added, to increase the fusibility of the oxide of tin formed, and thus allow the metallic copper to fall to the bottom. The most accurate experiments on this subject on a large scale, are those of Pelletier and Darcet, which were done by exposing the alloy to heat and air, and by the addition of black oxide of manganese.

In one of these, 400 lb. of alloy, known to be composed of 80 copper and 40 tin, were heated, and constantly stirred till they increased to 425 lb. 2 oz. These were added to 800 lb. of alloy brought to a state of fusion in a reverberatory furnace, and the mixture constantly stirred during 20 minutes, and occasionally afterwards for 9 hours. The fused metal was then drawn off, and amounted to 761 lb. 12 oz.; 7 lb. 4 oz. of metal were also obtained during the trials to ascertain its purity, and the scoria yielded 64 lb. more, making in all 833 lb.; that is, very nearly 70 parts of copper from the 100 of alloy, which contained 80 of this metal.

In another experiment, 800 lb. of alloy were melted in the furnace, and 25 lb. of oxide of manganese were added to them. The mixture was then well stirred, and in two hours afterwards 15 lb. more of manganese were thrown in, a similar quantity being added every two hours till the whole amounted to 100 lb. and the fusion and occasional stirring were continued during ten hours. At the expiry of this time, the copper was drawn off, and amounted to 520 lb. that is, 65 per cent. of the alloy employed. The scoria still retained a good deal of copper, but this was not extracted from it.

When the alloy contains silver, it may be assayed by dissolving it in nitric acid, precipitating the silver by muriate of soda, and the copper by a plate of iron.

Tin.

Different methods are followed in reducing the ores of tin.

The ore which is procured from the mines of Cornwall, after being *hand-dressed*, is freed from impurities by stamping, as has been described under gold, after which, it is roasted in a reverberatory, to drive off the sulphur, part of which, however, is acidified, and unites with the copper and iron of the ore. The ore is again washed, by which it is nearly freed from all impurities; it is then mixed with one-fifth of its bulk of culm, and subjected to heat in a reverberatory for about six hours, during which the oxide of tin is reduced, and the metal collects at the bottom, covered with a black scoria. The tin is then drawn off into a shallow pit, in which it is freed from the scoria which collects on its surface. It is then taken out with ladles, and poured into moulds.

The metal thus obtained is afterwards exposed to a gentle heat in a small reverberatory furnace, by which the purest part of it melts first, and is drawn off. This forms grain tin; what is left behind is common tin, which contains a small portion of iron, copper, and arsenic.

The water employed in the second washing of the ore contains a considerable quantity of sulphate of copper, on which account it is kept and decomposed by iron. The scoria separated from the tin, when drawn from the reverberatory, retains a good deal of the metal—it is therefore stamped and melted along with the ore.

The stream tin stone of Cornwall is melted in a different way. As the ore is in a powdery state when procured, it is submitted to a stream of water, by which a great deal of the impurities are removed. It is afterwards bruised, and passed through wire sieves.

It is then thrown, with alternate quantities of charcoal, into a blast furnace, in which it is reduced, and escapes through a channel at the bottom into pits; the scoria being removed as it collects, and thrown again into the furnace.

The metal is then put into a large iron pot, in which it is kept fused. When in this state, pieces of charcoal are plunged into it, which cause a fresh quantity of scoria to be separated. The metal is then *tried* by removing a quantity in a ladle, and pouring it into the pot. If it appear bright like silver, and of uniform consistence, it is pure. After this it is poured into moulds, and forms good grain tin.

Assay.—In assaying an ore of tin, it is first reduced to coarse powder, and then washed, to free it from earthy matter. If it contain arsenic, which is known by its emitting the odour of garlic when fused before the blow-pipe, it must be exposed to heat with charcoal, till the vapours of arsenic cease to be emitted. What remains is then mixed with pitch and saw-dust, subjected to a strong heat in a crucible, lined with charcoal. The metallic button collected at the bottom is tin.

Lead.

The only ore of lead from which the metal is extracted is galena, the smelting of which is very simple.

The ore after being brought from the mine is *hand-dressed*, by which it is freed as much as possible of impurities. What remains is then washed, to remove still farther any extraneous matter, and is put into a reverberatory furnace, where it is speedily made red hot. When in this state it is frequently stirred, and when it begins to become soft, the heat is reduced till the whole of the sulphur is expelled. The fire is then made brisk, by which the lead is melted, and collects at the bottom. A little lime is then thrown in to thicken the scoria, and the lead is drawn off into oblong moulds; a sufficient heat is again applied to the scoria, by which another portion of lead is procured. The lead obtained in the first operation is considered the best, as it is more malleable than the other.

Assay.—The assay of galena is very simple. It may be done either in the dry or the humid way.

The lead ore is first reduced to powder, and then digested in diluted nitric acid. To the solution, after filtration, sulphate of soda is added, which throws down the sulphate of lead: 100 gr $=$71 lead.

Or, the ore is first roasted, and then fused with thrice its weight of black flux, and covered with salt. The metallic button at the bottom of the vessel is the lead, containing the other metals present in the ore, which however are in very small quantity.

Should the ore contain silver, the metallic button thus obtained must be subjected to cupellation, or it may be dissolved in nitric acid, and muriate of soda added to the solution. The precipitate must then be digested in weak nitric acid, which will dissolve the muriate of lead, and leave the silver; 100 of the precipitate after this, when dried, $=$75.3 of silver.

Arsenic.

Arsenic very frequently exists with other metals. It is not, however, used in the metallic state in the arts. The compound of it generally employed is the white oxide, or, as it is commonly called, white arsenic, which is frequently obtained in the processes for extracting other metals from their ores.

White arsenic is obtained by subjecting the arsenic ores to heat, in large cast iron boxes, to which flues are closely luted. These are heated by flues from a furnace. When red hot, about 15 lb. of the ore are thrown in, and when the whole of the volatile matter has sublimed, another portion of ore is put in, and the process is continued for about 12 hours, during which time about 150 lb of the ore have been employed. What is collected in the flues of the boxes is broken off by hammers, and is freed from any foreign matter adhering to it.

Another preparation of arsenic much used in the arts, is yellow orpiment, which is procured in the same way; the ore being previously mixed with half its weight of sulphur.

Metallic arsenic is easily obtained from the white oxide, by heating it with carbonaceous matter; the sublimed metal being condensed in cool receivers.

Assay of Arsenic Ore.—The most accurate method of assaying an ore of arsenic, is that pointed out by Chenevix, which consists in acidifying the arsenic, and precipitating it by a salt of lead. For this purpose the ore is treated with nitric acid, so as completely to acidify the arsenic. Potassa is then added, and afterwards nitrate of lead, which throws down a precipitate, which, after exposure to a low red heat, must be weighed. If it is entirely soluble in nitric acid, 100 of it=22 of metallic arsenic.

If any of the precipitate is not soluble in nitric acid, it is sulphate of lead, the acid of which is formed by the action of the nitric acid on the sulphur of the ore. The weight of what is left, after the action of the nitric acid, will indicate that of the precipitate dissolved.

A more easy way of assaying the ore, though not quite so accurate, but sufficiently so for the purposes of art, is, to dissolve the ore slowly in muriatic acid, to which a little nitric acid is added. In this way the metal is dissolved, and the sulphur is left. The quantity of this indicates that of the arsenic; 100 being equivalent to about 138 of metal.

Cobalt.

Cobalt is not procured in its metallic state for the purposes of art. The preparation of it in general use is the oxide. Two different kinds of this are employed, zaffre and smalt; the former of which is the oxide mixed with a quantity of vitrifiable earth; the latter is the oxide which is brought to the state of glass by being exposed to heat with some fusible substance. These are prepared in Saxony, in Bohemia, Silesia, and Lorrain. That from the former is considered the best. To prepare zaffre, the cobalt ore is exposed to heat by means of the flame of wood, which is made to play on it. The vapour arising from the ore is conveyed through a long flue, in which it is condensed. After the vapours have ceased to arise, the ore is removed and reduced to powder, and a second time exposed to heat. It is again reduced to fine powder, and passed through sieves; and after this is mixed with powdered flints moistened. In this state it forms zaffre. Smalt is prepared by mixing the oxide of cobalt, obtained in the above process, with about equal parts of potashes and powdered flints. The mixture is exposed to heat in large pots, and frequently stirred, when in the fused state, during 10 or 12 hours. It is then taken out in ladles, and dropped into cold water, by which it is afterwards more easily reduced to powder.

The powdering of smalt is performed by large stone rollers, inclosed in cases of wood. When reduced to powder, it is of a fine blue colour, and is sometimes called azure blue. It is employed not only in the arts, to impart its colour to substances with which it is fused, but likewise in washing, to prevent linen from becoming yellow.

Cobalt is obtained in the metallic state by deflagrating 4 parts of smalt, 2 of nitre, and $\frac{1}{2}$ of charcoal. The residue of the deflagration must be again subjected to a similar process, and afterwards fused with 2 parts of black flux. The product of this operation, weighing about one-fifth of the smalt, is mixed with one-sixth of its weight of nitre, and the same quantity of black oxide of manganese, and exposed to a strong heat in a covered crucible for about an hour. By this process it is freed from iron; it still, however, retains a small quantity of arsenic; or the product of the deflagration may be dissolved in nitric acid, and carbonate of potassa added to the solution, as long as a brownish precipitate is thrown down; when, however, the precipitate falls of a violet colour, the addition of the salt must be discontinued. By this means we get quit of the iron, and leave the cobalt in union with nitric acid. The nitrate is then exposed to heat, the acid is expelled, and the oxide may be reduced by fusion with black flux. By these processes cobalt is obtained sufficiently pure for many purposes.

Assay.—The assay of cobalt ore may be performed, though not with great accuracy, in the dry way. The ore is mixed with saw-dust, and roasted to expel the arsenic, and the residue afterwards exposed to an intense heat for about 15 minutes, with its own weight of a mixture of carbonate of potassa and tartar. The metallic button collected below is cobalt. The scoria of this operation contains a considerable quantity of metal; the whole of the cobalt is therefore not procured, and it is even doubtful if by this means the whole of the arsenic is expelled.

Mercury.

Different methods are practised for procuring mercury from its ores; they are however all very simple.

In Spain the cinnabar is collected and divided into three portions.

1st, The richest part of the ore.

2d, That which contains less metal.

3d, The powder of the two first.

These are exposed to heat in a furnace, by which the mercury is expelled. The furnace employed in this operation is of a particular construction. It consists of a long horizontal building, divided into an under and an upper compartment, by a grating of iron. On this are placed flat rough stones, over which ore No. 2. is first put, and then ore No. 1. A layer of ore No. 2. is placed above this; and on the top of the whole is laid ore No. 3. made into a sort of bricks, with clay kneaded and dried. Wood is then kindled in the lower compartment of the furnace, by which the moisture is driven off. The fire is then continued till the sulphur begins to burn; after which the heat excited by the combustion of the sulphur is sufficient to volatilize the mercury, which is condensed in the receiver attached to the furnace. Along with the mercury there is collected a quantity of sooty matter, which is removed by placing the metal on an inclined table.

In this process there is a considerable loss of mercury, as the sooty matter which is thrown away retains a great deal of the metal.

In Germany, the finer part of the ore is separated from the coarser part, and is reduced to powder. It is then mixed with about one-fifth of slaked lime, and put into iron retorts, each of which holds about one-half cwt. From 40 to 50 of these are built into a furnace, and have receivers adapted to them. Heat is applied to the retorts, by which watery vapour is at first expelled. The receivers are then luted by means of clay, and the mercury which comes over is condensed in them. By this process 100 lbs. of ore yield from 6 to 10 oz. of mercury.

Assay.—The assay of the ore of mercury is very simple. Cinnabar, the ore usually employed for yielding the metal, is reduced to powder, and digested in nitro-muriatic acid, composed of one of nitric and three of muriatic acid, diluted with water, till the whole of the soluble matter is extracted. Carbonate of potassa is then added to the solution, and the precipitate, after being dried, is mixed with lamp-black, and exposed to heat in a retort, to which a receiver is adapted. By this means the mercury is expelled in the metallic state.

The ores of mercury which contain silver are assayed in the same way, so as to ascertain the quantity of mercury. The insoluble residue is then roasted, to drive off the sulphur, after which it is mixed with twice its weight of pearl-ashes, and again exposed to heat in a crucible. The product is then digested in muriatic acid, which dissolves the alkali, and leaves the silver in its metallic state.

A more easy way of assaying the mercurial ores is to reduce them to powder, and to mix them with one-fourth part of lime, and as much iron filings, and then expose them to heat in an iron or earthenware retort, by which the mercury is expelled, and is collected in a receiver.

Manganese.

Manganese is not used in the arts in its metallic state. The black oxide, which is a native production, answers, without any preparation, all the purposes for which the metal is employed.

Zinc.

The ores of zinc used in metallurgy, are calamine and blende. From these the metal is procured by a very simple process. The ore, after being hand-dressed, to free it from foreign matter, is roasted, by which the sulphur of the former and the acid of the latter are expelled. The product is then washed, by which the lighter matter is separated, and the heavy part which remains is mixed with one-eighth of its weight of charcoal. The mixture is next reduced to powder in a mill, in which state it is put into the pots to be smelted. The pots in which the smelting is performed resemble oil jars in shape. Through the bottom of each there passes a tube, the upper end of which terminates by an open mouth near the top of the pot, the lower end goes through the floor of the furnace into water. The pots are filled to the upper end of the tube with the mixture of ore and charcoal, and an intense heat is applied to them, by means of a furnace. As the ore is reduced, the zinc is volatilized, and escapes through the tube into the water, where it is condensed in the form of globules. These are afterwards melted and cast into moulds.

Zinc, as thus procured, is not pure; it almost always contains iron, manganese, arsenic, and copper.

To free it from these, it is again melted, and then well stirred along with sulphur and fat, the former of which combines with the foreign metals, and leaves the zinc nearly pure, while the latter prevents this metal from being oxidated.

Assay.—The assay of zinc ores may be performed in two different ways.

The simplest is, reducing the ore by charcoal. For this purpose, after being freed from impurities, it is roasted, to drive off the sulphur. It is then mixed with one-half its weight of charcoal in powder, and exposed to a strong heat, for about an hour, in an earthen retort, the mouth of which terminates in water. The zinc condensed in the water and in the neck of the retort is collected and weighed.

The second method of assay is, to expose to a strong heat for about an hour the mixture of ore and charcoal, in a covered crucible, with slips of copper, by which means the two metals unite. After the process is finished, the product is washed, and the weight which the copper has acquired indicates the quantity of zinc in the ore.

Bismuth.

Bismuth occurs native and mineralized by oxygen and sulphur, and is very easily obtained from its ores.

When native bismuth, and the oxide, are employed to yield the metal, they are merely exposed to heat, in contact with fuel, generally in shallow pits dug in the earth. The metallic matter which collects at the bottom is then mixed with an equal weight of black flux, and put into a crucible, and covered with common salt, to about the depth of half an inch. A strong heat is applied for a short time, by which the mixture fuses, and the bismuth collects at the bottom of the pot.

Instead of the above process, the ore is sometimes mixed with half its weight of borax and of pounded glass, and subjected to heat in a crucible lined with charcoal.

When the sulphuret of the metal is employed, it is first roasted by a gentle heat, to drive off as much of the sulphur as possible. After this, it is mixed with black flux, and subjected to heat, covered with common salt, as in the first process.

Bismuth obtained by these different processes contains in general lead, silver, or cobalt, provided these were present in the ore; it is sufficiently pure, however, for most purposes.

Assay.

The assay of the ores of bismuth, with the view of ascertaining the quantity of that metal, is performed by means of nitric acid. The ore is dissolved in this acid, diluted with one-half its weight of water, by the aid of heat. To the solution, a large quantity of water is added, by which oxide of bismuth is precipitated. The fluid after filtration is then evaporated as far as possible, without causing the deposition of any of its ingredients. Muriatic acid is then added, and the precipitate is digested in nitric acid. With the solution thus obtained, a large quantity of water is mixed, and the whole of the oxide of bismuth is thrown down. This, with the former precipitate, is then fused with black flux, by which the bismuth is procured in the metallic state.

If the ore contain silver, the precipitate thrown down by muriatic acid will become black on exposure to light.

To ascertain the quantity of this metal present in the ore, the residue of the precipitate, after the digestion in nitric acid, must be washed, and then exposed to a red heat, 100 gr. of it = 75.3 of silver.

Or, the metallic button, obtained by the fusion of the ore with black flux, may be subjected to cupellation, by which the base metals will be oxidated, and absorbed by the dish, and the silver will be left.

Antimony.

The sulphuret of antimony is the only ore of this metal that is used in commerce. This is purified merely by fusion, in which state it is usually employed in the arts. For purifying the sulphuret, two methods are employed.

1*st*, The ore, after being broken, and freed as much as possible from stony matter, is put into a large crucible, in the bottom of which there is a small hole. From this there proceeds a tube, which passes through the furnace in which the crucible is placed, and terminates in a reservoir. As the heat is applied, the sulphuret fuses, and runs through the tube into the reservoir, while the stony matter is left in the crucible.

2*d*, The fragments of the sulphuret, after being freed from the earthy ingredients, are put on the hearth of a reverberatory furnace, and covered with charcoal. They are then brought to the fluid state, while the foreign ingredients float on the surface, and are removed by ladles. When fluid, the sulphuret is poured into moulds, in which state it forms common, or crude antimony.

From the crude antimony the metal is procured by different processes. The first of these is, by what is called *scorification.* For this purpose 8 parts of finely powdered sulphuret are mixed with 6 of crude tartar and 3 of nitre, and the mixture is thrown in successive portions into a red-hot pot. When the vessel is nearly filled, it is covered, and a strong heat is applied to it for about half an hour; the fused matter is then either allowed to cool, or it is poured into a conical iron vessel, greased in the inside, in which it separates into different layers; the upper consisting of scoriæ of alkaline matter and oxide of antimony; the lower one of antimony in its metallic state.

It has been recommended by some to deflagrate the nitre and tartar, previous to the sulphuret being mixed with them; as, however, the use of the nitre is to acidify the sulphur, it is best to mix the whole of the substances together, and then to deflagrate them. In this process it is necessary to avoid using an excess of tartar and nitre, otherwise not only the expense is increased, but less metal is obtained. The proportions above stated are what Lemery found to answer best.

The second method of reducing the sulphuret is by *roasting* The ore, reduced to small pieces, is placed on the hearth of a reverberatory furnace, and heat is applied to it, by which the sulphur is consumed, and the antimony is oxidated. In this part of the process it is necessary that the heat be at first slight, otherwise the sulphuret runs into cakes. As the sulphur is consumed, and the fusibility diminishes, the residue is brought to a red heat. When it ceases to emit the odour of sulphurous acid, the roasting is stopped, and the oxide is removed. In this state it still contains a small quantity of sulphuret.

Different methods are followed for procuring the metal from the oxide. It is sometimes mixed with one half its weight of crude tartar, and exposed to a strong heat, in covered vessels, by which the oxygen of the oxide unites with the carbon of the acid of the tartar; and the metal, in a state of fusion, falls to the bottom of the vessel. There is also formed a compound of the antimony with the sulphuret of potassa, which is generated by the union of the alkali of the tartar with the sulphur contained in the oxide. The quantity of metal obtained by this process amounts to about 70 per cent. of the oxide employed, and 100 of the sulphuret yield about 70 of oxide.

Another method of procuring antimony, is by melting the oxide along with fat and charcoal. When the mixture is in a state of fusion, nitre, in the proportion of about 1 oz. to the pound, is gradually added. The whole is then poured out, and allowed to cool. By this means more of the metal is procured than by the above process.

The third method of obtaining antimony, is by adding some body as a metal, which unites with the sulphur. For this purpose iron is always employed. In decomposing the sulphuret in this way, 8 parts of iron, in small pieces, are heated to whiteness in a crucible; 16 parts of coarsely powdered sulphuret are then added, and the vessel is covered for a short time. When the whole is in fusion, 3 parts of nitre are gradually thrown in, and the product, after a short time, is poured into greased cones, which must be gently struck from time to time, as the matter consolidates, to cause the metal to fall to the bottom. When the whole has become solid, about 10 parts of antimony are found in the vessel, which, however, still retains iron and sulphur. To free it from these, it must be again melted with 3 parts of nitre, and 2 of sulphuret, which must be repeated twice before the antimony is obtained pure. From 18 of sulphuret 8 of metal are procured by this process.

Assay of the Sulphuret.

Sulphuret of antimony, besides sulphur and antimony, contains also lead, iron, copper, stony matter, and occasionally silver. The assay, with the view of ascertaining the quantity of antimony, is, however, easily performed, by digesting the sulphuret in nitric acid. After the action has ceased, the solution is poured off, and the insoluble residue is dissolved in nitro-muriatic acid. To the solution, a large quantity of water is added, and the precipitate thrown down, is mixed with twice its weight of crude tartar and a little nitre, and exposed to heat, by which the antimony is obtained in the metallic state

METALS. The metals, if we except the bases of the alkalies, and earths, are distinguished by hardness and tenacity, great specific gravity, opacity. and peculiar brilliancy, generally termed metallic lustre.

The properties of the metals have been already described in the article Chemistry. At the time when that article was written, they amounted to 27.

1 Iron.	Arsenic.
Copper.	Manganese.
Lead.	10 Gold.
Zinc.	Silver.
5 Tin.	Platinum.
Mercury.	Iridium.
Antimony.	Osmium.

15 Rhodium.	Chromium.
Palladium.	Titanium.
Bismuth.	Tungsten.
Cobalt.	25 Tantalum.
Nickel.	Cerium.
20 Molybdena.	27 Uranium.
Tellurium.	

Since then, three new metals have been discovered, and an account has been given of a fourth, of the existence of which, however, considerable doubts are entertained.

The three first are Selenium,
Cadmium,
Wodanium.
The other is Vestium, or Sirium.

Selenium.

The sulphur procured from the pyrites of Fahlun, when employed in the preparation of sulphuric acid, was observed by Bjuggren to leave a reddish brown substance, which, by some chemists, was supposed to contain arsenic; on which account the use of the pyrites of Fahlun was discontinued. Berzelius has subjected this brown matter to analysis, and has discovered, that besides iron, copper, lead, zinc, tin, mercury, and arsenic, it contains a peculiar substance, possessed of metallic properties, to which he has given the name of selenium, (from selenė the moon,) to recal its analogy with tellurium, which it very much resembles.

Berzelius, in his analysis of the brown matter left after the preparation of sulphuric acid, digested it in nitro-muriatic acid Water and sulphuric acid were then added; and the mixture was filtered, by which sulphur and sulphate of lead were separated. To a portion of the filtered fluid ammonia was added, which threw down a precipitate, which, when heated with potassium, was decomposed with ignition. This precipitate was partly soluble in water; the solution acquired a brown colour; and, on the addition of nitric acid, deposited a reddish substance, which, when brought in contact with flame, communicated to it a blue tinge, and emitted the odour of horse raddish. This made Berzelius suppose that it contained tellurium; but he afterwards found that it was caused by the new metal When the fluid which had yielded the precipitate on the addition of ammonia was subjected to distillation, a yellowish liquid was collected, which contained sulphurous acid, and deposited a brown powder. A black substance was sublimed into the neck of the retort. The fluid, when boiled, deposited more of the brown powder; and the sublimate, when washed, afforded the same matter. These were selenium.

To procure selenium free from the other substances contained in the pyrites, Berzelius passed sulphuretted hydrogen through the fluid obtained by filtration, after the digestion of the substance in nitro-muriatic acid

a By this means, an orange-coloured precipitate was produced, which was treated with nitro-muriatic acid.

b Water was added to the solution, which occasioned a copious white precipitate.

c This, when heated to redness, yielded a chrystalline sublimate, having a strong acid taste; and when subjected to heat with soda and borax, it left a metallic button, possessing the properties of tin. It was therefore an oxid of tin, in union with the sublimed acid, which Berzelius found was an acid of selenium

d To the liquid from which the above precipitate was obtained, muriate of baryta was added, which threw down the sulphuric acid. The fluid, after filtration, being subjected to heat, afforded a white chrystalline sublimate, and a whitish matter was left behind.

e The sublimate (*d*) was an acid having a metallic taste, communicated to it by mercury; for when precipitated by potassa, it yielded mercury on the application of heat. What remained was potassa in union with the acid.

f This, when mixed with muriate of ammonia, and distilled, first yielded water and ammonia. Selenium then sublimed in small quantity. The residue, when washed, left a coarse brown powder. which was selenium, and which was sublimed to free it from impurities.

g The substance left after the distillation (*d*) was found to consist of baryta, copper, and tin, in union with the acid of selenium, and of arseniate of baryta.

Selenium is of different colours, according to the mode in which it is prepared. After being fused, it has a deep brown colour, and metallic lustre. When allowed to cool slowly, its surface becomes rough. In the former case, the fracture is conchoidal, and presents the appearance of lead; in the latter, it is granular, and resembles a piece of cobalt.

When, on the contrary, selenium is precipitated from some of its combinations, it assumes a cinnabar-red colour; and in some particular cases, the colour approaches that of gold. When selenium is in powder, it is red; but when pounded, it sticks together, and becomes grey.

The specific gravity of selenium is 4.32. It is a bad conductor of caloric; a small piece of it, which is heated to near the fusing point at one end, may be held by the other end in the hand. It is a very imperfect conductor of electricity; and, what is remarkable, it has not been made electric by friction.

When selenium is heated to 212°, it becomes semi-liquid, and, at a few degrees higher, it fuses. As it cools, it becomes semifluid, and then passes into the solid form. When semifluid, it may be drawn into fine threads, or beat into plates, which when thin, are transparent. These, when viewed by transmitted light, are red, by reflected light they are grey. Selenium may be made to assume the chrystalline state, though with difficulty. When slowly deposited from a solution of some of its salts. it puts on the dendritic form, the chrystals of which appear, by the aid of a glass, to be prisms terminated by pyramids.

When selenium is heated in close vessels, it boils, and passes off in vapour, of a colour rather darker than that of chlorine, and which condenses in the cool part of the apparatus in black drops.

When heated in the air, or in very large vessels, a red-coloured vapour is formed, which condenses in powder. When the metal is heated in contact with flame, the flame acquires at its edges a blue colour, and the selenium is volatilized, with the odour of horse-raddish. The products in this case are selenic acid, and a compound of selenium and oxygen, similar to carbonic oxide. Berzelius has therefore called it selenic oxide.

Selenic oxide is procured by washing repeatedly the product formed in the above experiment. It may likewise be obtained by heating selenium in a large vessel containing oxygen, or by dissolving the compound of the metal and sulphur in nitro-muriatic acid. It is sparingly soluble in water, but communicates to that fluid its peculiar odour. It does not seem to unite with the alkalies.

Selenic Acid. Selenium combines with a larger proportion of oxygen, and forms a compound possessed of acid properties. When a stream of oxygen is passed over selenium in a state of fusion, the metal takes fire, and burns with a white flame, having a greenish tinge at the edges; the product is selenic acid, which condenses in the cool part of the apparatus. Selenic acid is more easily procured by dissolving selenium in nitro-muriatic acid. By evaporating the solution, the undecomposed acids pass off, and selenic acid is left in the form of a white mass. When this is subjected to a higher temperature it volatilizes without becoming fluid. The temperature at which it passes into vapour seems to be below that of boiling sulphuric acid. The vapour has exactly the appearance of chlorine, and condenses in the cool part of the apparatus, in long four-sided needles.

Selenic acid has a sour taste, leaving a burning sensation on the tongue. It is very soluble in cold water, and in almost any quantity of that fluid at a boiling heat. The solution on evaporation deposits acicular crystals, but by cooling slowly a saturated warm solution, the acid assumes a prismatic figure.

Selenic acid forms saline compounds with the alkalies, earths, and metallic oxides. It is soluble in alcohol, and yields, on distillation with this fluid, a liquid having an etherial odour; at the same time a portion of selenium is formed, and part of the acid remains behind.

Berzelius endeavoured to ascertain the composition of this acid, by passing chlorine over the metal. In this experiment, 1 of selenium united with 1.79 of chlorine. According to Berzelius, 1.79 of chlorine are equivalent to 4.043 of oxygen—100 of selenium, therefore, unite with 40.43 of oxygen, to form selenic acid.

In another experiment, the product formed by passing the gas over selenium was dissolved in water, and the muriatic and selenic acids generated, were precipitated by nitrate of silver. The precipitate, after the seleniate was removed by boiling diluted nitric acid, weighed 7.2285 = 1 38 of muriatic acid = 40.274 of oxygen. According to this experiment, 100 of selenium combine with 40.274 oxygen.

Berzelius is inclined to consider, that the true composition of the acid is

100 selenium, 71.26,
40 33 oxygen, 28.74;

and that it contains 1 atom of selenium, and 2 of oxygen. If so, the number for selenium is 4.959, that of oxygen being 1.

Dr. Thomson, from calculation founded on the former of these experiments, infers that the acid is composed of

100 selenium,
38 oxygen.

The cause of this difference is owing to a difference entertained with respect to the constitution of the precipitate, afforded by the nitrate of silver. According to Dr. Thomson, the equivalent number for selenium is 5.125, that for the acid 7.125.

Chloride of Selenium.—When selenium is kept in chlorine, the gas is absorbed, the metal becomes hot, and a brown-coloured liquid is formed, which assumes a white colour as the absorption of the gas proceeds. According to Berzelius, the product of this experiment is selenic and muriatic acids. According to Sir H. Davy's doctrine, it is a chloride. When dissolved in water, it forms a transparent colourless acid solution.

When this compound is heated in contact with selenium, a yellowish fluid is formed, which, when put into water, decomposes it, and generates muriatic and selenic acids, and deposits selenium. It is probable that this is another compound of selenium and chlorine, containing less chlorine. If so, it is the protochloride, and the former is the perchloride of the metal.

Seleniuretted Hydrogen.—Selenium combines with hydrogen, and forms a gaseous fluid, called seleniuretted hydrogen, which is procured by adding muriatic acid to the compound called seleniuret of potassa. It is absorbed by water, forming a transparent colourless solution, having a hepatic taste, and which stains the skin red, and reddens litmus. The solution, after being kept for some time, becomes turbid, from the deposition of selenium. When exposed to the air, the seleniuretted hydrogen is decomposed. The same takes place when the gas is brought in contact with a moist body, and what is remarkable, the selenium penetrates the substance, if porous, and communicates to it a red colour.

Nitric acid causes no change on the solution of seleniuretted hydrogen in water.

The solution, when added to the metallic salts, throws down precipitates from them, which are in general black or brown. Those from a salt of zinc, manganese, and cerium, are however of a red colour. The former are considered seleniurets, the latter hydroseleniurets, and according to Berzelius, when exposed to the air, are converted into seleniurets of the oxide of the metals.

Seleniuretted hydrogen produces remarkable effects on the organs of respiration. When admitted into the nostrils, it excites a painful sensation, and destroys completely for several hours the sense of smell, followed by severe catarrh, deep pain of the chest, and expectoration of mucus, having the taste of the vapour of corrosive sublimate.

These effects are produced by a very minute quantity of the gas. Berzelius supposes that the seleniuretted hydrogen is decomposed by the moisture, and that the selenium adheres to the membrane of the nostrils and trachea. The eyes are likewise affected with inflammation when exposed to this gas.

Seleniuretted hydrogen, according to the experiments of Berzelius, is composed of

97.4 selenium,
2.6 hydrogen.

This compound of selenium may be considered analogous to sulphuretted hydrogen.

No compound of selenium and carbon has yet been formed, though from some experiments, it is conjectured that these bodies do unite.

Phosphuret of Selenium is formed, when selenium and phosphorus are heated together. The compound is fusible, and is of a dark colour, having a vitreous fracture. When digested in water, it decomposes this fluid; seleniuretted hydrogen is formed, and selenium is deposited.

Sulphuret of selenium may be procured by passing a stream of sulphuretted hydrogen through a solution of selenic acid, and then adding a few drops of muriatic acid, by which the sulphuret of selenium is precipitated of an orange colour. This compound is very fusible, passing into the liquid state at a temperature a little below that of boiling water. By the application of a stronger heat it volatilizes, and again condenses of an orange colour. Sulphuret of selenium, when heated in the air, burns, and emits the odour of sulphurous acid and of horse-raddish. When exposed to heat with selenic acid, it is decomposed, and the sulphur combines with the oxygen.

This compound is not easily acted on by nitric acid; nitro-muriatic acid, however, dissolves it.

Sulphuret of selenium is composed of

100 selenium,
60.75 sulphur.

Selenium, and the alkalies and earths.—By the action of selenium on the alkalies and earths, compounds are formed, analogous to those generated by the action of sulphur on these bodies. It is probable, therefore, that they are compounds of the bases with seleniuretted hydrogen, having the selenium in excess. If so, they are seleniuretted hydro-seleniurets.

When aqua potassæ is boiled on selenium, a solution is formed, having the colour and odour of sulphuretted hydro-sulphuret of potassa. The same compound may be obtained by exposing to heat selenium and potassa, or its sub-carbonate.

When an acid is added to the solution of this substance, selenium is precipitated.

Ammonia does not, either in the state of gas, or in solution in water, act on selenium.

When seleniuretted hydro-seleniuret of lime and muriate of ammonia are subjected to heat a reddish-coloured fluid distils over, which, when exposed to the air, emits ammonia, and deposits selenium. By the addition of a large quantity of water to it, selenium is also precipitated. There is left in the retort after the distillation, muriate, seleniate, and hydro-seleniate of lime. When selenium and lime are exposed to heat the two unite, and form a black substance destitute of taste and smell, and insoluble in water. On the addition of an acid to this, the selenium is left in the form of a spongy mass. This compound may be got crystallized, by exposing to the air a solution of hydro seleniuret of lime. The crystals appear to be four-sided prisms, with truncated summits.

The compounds formed with baryta, strontia, magnesia, and alumina, are insoluble. By the addition of an acid to them the selenium is separated, and the two last yield that metal on the application of heat.

Selenium and the metals.—Selenium combines with the metals, presenting with most of them the same phenomena as sulphur.

The seleniurets have in general a metallic aspect, and are usually more fusible than the metals which they contain. By the application of heat to them, the selenium burns with a blue flame, emitting the odour of horse-raddish.

Seleniuret of potassium.—When selenium and potassium are heated together, they combine, and during their union emit caloric, sufficient to raise the temperature of the compound to ignition, by which a portion of selenium is sublimed.

Seleniuret of potassium resembles iron in appearance, having a crystalline structure. When thrown into water, decomposition ensues, and hydro-seleniuret of potassa is formed. The solution is of a reddish colour, and possesses the property of keeping dissolved an excess of selenium, for, when nitric acid is added to it, selenium is deposited.

When selenium is heated with an excess of potassium, an explosion occurs, and the product is scattered about by the potassium which is converted into vapour. The compound formed in this instance, when put into water, is dissolved, and hydrogen is disengaged.

Seleniuret of iron may be procured by passing the vapour of selenium over iron filings, at a high temperature; during the union, caloric is evolved. The compound has a dark-grey colour, and metallic aspect. It is hard and brittle, with a granular texture. When heated at the flame of a candle, part of the selenium is volatilized. Seleniuret of iron, when acted on by muriatic acid, affords seleniuretted hydrogen. In this case the first portion of gas disengaged is decomposed by the air in the apparatus, and selenium is deposited, which gives to the liquid a reddish colour. Along with seleniuretted hydrogen, another gaseous fluid is given out, which has a disagreeable odour, is inflammable, and is not dissolved by water, nor by the solutions of the alkalies. When passed through a solution of proto-nitrate of iron, a black precipitate is thrown down.

Selenium unites with a less proportion of iron, and forms a compound not soluble in muriatic acid, and which, by exposure to heat, parts with the excess of selenium.

Seleniuret of copper is formed by passing seleniuretted hydrogen through a solution of copper, by which a dark-grey substance is precipitated, which, on exposure to heat, loses half of its selenium. and proto-sulphate of copper is left behind. This compound may also be procured by heating selenium and copper-filings together.

Seleniuret of lead—Selenium and lead unite with an evolution of caloric. The seleniuret is of a grey colour, and porous. When heated before the blow-pipe on charcoal, part of the selenium is oxidized, and sub-seleniate of lead is formed, which is afterwards decomposed, and seleniuret of lead is regenerated.

Selenium unites with more lead, and forms a compound less fusible than the former.

Seleniuret of tin is of a grey colour, and possesses the metallic lustre in a high degree. When exposed to heat, the selenium is volatilized, and the tin is oxidated.

Seleniuret of zinc.—When selenium and zinc are heated together, the melted selenium covers the surface of the zinc, but does not combine with it. If the heat be increased much above the fusing point, the former is volatilized, and the latter remains covered with a yellow pellicle.

When zinc, at an elevated temperature, is introduced into the vapour of selenium, an explosion occurs, and the vessel is lined with a lemon-coloured powdery substance, which is seleniuret of zinc. This is soluble in nitric acid, with the disengagement of nitric oxide.

Seleniuret of mercury.—When selenium and mercury are heated together, a substance resembling tin is formed. If mercury be in excess, this is expelled, when the compound is subjected to heat; the seleniuret then sublimes without fusing, and condenses in the form of white leaves, having a metallic lustre. Seleniuret of mercury is not easily acted on by nitric acid. When this is boiled on it, proto-seleniate of mercury is formed, and the nitric acid contains selenic acid. If muriatic acid be poured on the seleniate, selenium is precipitated; the oxygen of the selenic acid passing to the mercury, by which the red oxide is generated. Seleniuret of mercury is soluble in nitro-muriatic acid.

Seleniuret of antimony has a metallic lustre and a crystalline appearance.

Seleniuret of arsenic.—When arsenic is put into fused selenium, the two metals unite, and a black mass is produced, which, when heated to redness, boils, and a sublimate is formed, which appears to be per-seleniuret of arsenic.

Seleniuret of platinum.—Platinum in powder, and selenium, readily combine with the extrication of caloric, and generate a grey substance, which, when subjected to heat, parts with the selenium, and leaves the platinum. On this account the seleniates act readily on a platinum crucible.

Seleniuret of palladium is of a grey colour, and before the blow-pipe emits part of the selenium.

Seleniuret of bismuth has a silvery colour and metallic lustre, and requires a red heat for its fusion.

Seleniuret of tellurium is fusible, and sublimes in the form of a metallic mass—it is also oxidated, and generates seleniate of tellurium.

Selenic Acid and Bases.

The affinity of selenic acid for the bases seems to be below that of arsenic acid. The neutral seleniates are either insoluble, or sparingly soluble in water. Berzelius asserts that the acid of them contains just as much oxygen as exists in the base. The quantity of oxygen in a base sufficient to saturate 100 of acid is 14.37.

Selenic acid forms two classes of super-salts; the first contains twice as much acid as exists in the neutral compounds, of course there is four times the quantity of oxygen that there is in the base. These salts Berzelius calls bi seleniates. The other super-salts appear to contain four times the acid of the neutral compound; they are therefore termed quadri-seleniates.

Selenic acid forms also sub-salts with the alkalies, and with some of the metals. The alkaline seleniates have a saline taste. Those, with the earths and the metals, possess in general the taste of the base.

The compounds of selenic acid are decomposed by heat, which seems to be occasioned by their containing foreign inflammable matter. The same occurs when the seleniate of an alkali or earth is heated with charcoal. Carbonic acid and carbonic oxide are formed, and a small quantity of selenium sublimes. When a metallic seleniate is treated in this way, the selenium unites with the metal of the base, and forms a seleniuret.

Seleniate of potassa is very soluble in water, and may be obtained in small metalline grains by the evaporation of the fluid. When evaporated to dryness, the residue attracts moisture on exposure to the air. When heated to redness it fuses, and becomes of a yellow colour, but again assumes its former appearance when it cools. It is insoluble in alcohol.

Bi-seleniate of potassa is deliquescent, and soluble in water, but crystallizes with difficulty. By the application of long continued heat, half of the acid is driven off. This salt is sparingly soluble in alcohol.

Quadri-seleniate of potassa cannot be obtained crystallized. It is very deliquescent.

Seleniate of soda has the taste of borax. It is very soluble in water, and affords, on evaporation, small crystalline grains, which do not deliquesce. It is not soluble in alcohol. By exposing this salt with muriate of ammonia to a red heat, muriate of soda is left. In this way 100 of seleniate afforded 66$\frac{2}{3}$ muriate of soda = to 35.5 soda. The salt is therefore composed of

64.5 acid.
35.5 soda.

Bi-seleniate of soda is obtained in the crystalline state. When heated, it undergoes fusion; and if the heat be strong, it parts with its excess of acid, and forms the seleniate. This salt is composed of 77.83 acid,
22.17 soda.

Quadri-seleniate of soda crystallizes in needles. It does not alter by exposure to the air.

Seleniate of ammonia is obtained in four-sided prisms, which are deliquescent.

Bi-seleniate of ammonia is obtained by exposing a solution of the preceding salt to the air; and the

Quadri-seleniate of ammonia is procured by adding selenic acid to a solution of the bi-seleniate, or by evaporating the solution by heat.

Seleniate of ammonia is decomposed by heat, water and ammonia are first disengaged; the selenic acid is then decomposed by the ammonia, and selenium is left in the retort.

Seleniate of lime is sparingly soluble; when heated in a glass vessel it forms bubbles in the glass, and at last perforates it.

Bi-seleniate is formed by dissolving the above salt in the acid.

Seleniate of baryta is insoluble in water. It is composed of 100 acid,
137.7 earth.

Bi-seleniate is formed by dissolving carbonate of baryta in selenic acid. It is soluble, and crystallizes. It is composed of 100 acid and about
68 baryta.

Seleniate of Strontia is insoluble.

The *bi-seleniate* is sparingly soluble in water. By the application of heat, the excess of acid is expelled.

Seleniate of magnesia is sparingly soluble. It attacks glass in the same way as the seleniate of lime.

Seleniate of alumina is formed by adding bi-seleniate of ammonia to muriate of alumina. It is decomposed by heat giving out its acid.

Seleniate of glucina is insoluble in water.

Seleniate of zirconia is also insoluble.

Proto seleniate of iron. Selenic acid acts with difficulty on iron. When a salt of iron containing the black oxide is added to a solution of an alkaline seleniate, the proto-seleniate of iron is precipitated. This salt is decomposed by heat, and the oxide of the metal is reduced.

The *bi-seleniate* is obtained by dissolving the seleniate in the acid, or by adding the salt of iron to a solution of an alkaline bi-seleniate.

Per-seleniate of iron is procured by double decomposition. It is of a yellow colour, and yields its acid by the application of heat.

Proto-seleniate of copper is obtained by dissolving the protoxide of the metal in selenic acid. It is of a white colour.

The *per-seleniate* may be formed by mixing sulphate of copper and bi-seleniate of ammonia. It is insoluble, and affords its acid by heat.

Seleniate of lead is formed by mixing muriate of lead with seleniate of ammonia in excess. It melts on the application of caloric, and at a white heat it is decomposed, and sub-seleniate is left in the vessel.

Seleniate of zinc is insoluble; the *bi-seleniate* is soluble; the former, when exposed to heat, generates the *sub-seleniate*.

Per-seleniate of tin is a white powder, insoluble in water, but soluble in muriatic acid. It yields its acid by heat.

Proto-seleniate of mercury. Selenic acid, when added to a salt of mercury, containing protoxide, throws down a white precipitate. This salt is decomposed by potassa, the alkali uniting with the acid. Muriatic acid combines with the oxide and a little of the acid, and leaves selenium reduced.

Per-seleniate of mercury is a white insoluble powder. The *bi-perseleniate* is formed by dissolving peroxide of mercury in selenic acid, and evaporating till crystals are formed. When a solution of this salt is mixed with sulphurous acid, proto-seleniate of mercury and selenium are precipitated.

Seleniate of manganese is a white powder, which, when exposed to the air, attracts oxygen, and the acid is disengaged. This salt possesses the property of destroying glass.

Seleniate of silver is white. It is soluble in boiling nitric acid, and when water is added to the solution, it is deposited in acicular crystals. It is composed of

100 acid,
205.75 base.

Seleniate of cobalt is a rose-coloured insoluble powder.

Seleniate of nickel, when dry, is pale green.

Proto-seleniate of cerium is a white powder, soluble in selenic acid, forming *bi-seleniate*.

Per-seleniate of uranium is a yellowish powder, which is decomposed by heat. It is soluble in selenic acid, and forms *bi-perseleniate*.

Seleniuretted hydrogen and bases. The hydro-seleniurets of the fixed alkalies are easiest formed by passing a current of the gas through a solution of these bodies. When seleniuretted hydrogen and ammonia in the state of gas are brought into contact, they combine and form a powder of a pale red colour.

The hydro-seleniurets of lime, baryta, strontia, and magnesia, are soluble. The hydro-seleniurets of the other earths are insoluble.

Berzelius has not examined particularly the properties of the hydro-seleniurets. When seleniuretted hydrogen was passed through lime water, a reddish powder was precipitated. The clear liquor kept in a phial, not well stopped, became red on the surface, which gradually descended, till the whole acquired the same colour. A reddish substance was then deposited, and the fluid became colourless. According to Berzelius, the coloured solution contained seleniuretted hydro-seleniuret of lime. The hydro-seleniurets of the alkalies are likewise decomposed when kept in contact with air, and selenium is separated, forming a pellicle on the surface of the fluid. If the separation of the metal occur slowly, and if the vessel be not agitated, the selenium is deposited in the dendritic form.

All the metallic solutions are precipitated by the alkaline hydro-seleniurets. The precipitates from the salts of zinc, manganese, cerium, and probably also uranium, are hydro-seleniurets. Those from the other metallic salts are seleniurets.

From the properties of selenium we may consider it as more nearly allied to sulphur than to any other substance; at the same time its high metallic lustre and specific gravity would induce us to class it among the metals. Berzelius thinks that it belongs to the division of these bodies, called electro-negative, or those which, by their combination, generate acids; among these are arsenic and tellurium, to which also it seems nearly allied.

It may be considered as another substance added to that class of bodies which generate acids by their union both with oxygen and hydrogen.

Berzelius has found selenium in two other minerals, the one of these is a seleniuret of copper, mixed with carbonate of lime, the other, which was obtained from a copper mine of Skrickerum, he found contained

Silver	38.93
Copper	23.05
Selenium	26.00
Foreign earthy matter	8.90
Loss	3.12
	100.00

Cadmium.

Professor Stromeyer, when examining a compound of zinc, prepared at the chemical laboratory of Salsgitter, which was supposed to contain iron, from its acquiring a yellow colour when heated, discovered that this property was owing to the presence of a peculiar metal not previously known, to which he has given the name of cadmium. He has since found this substance in tutia, and in several of the other compounds of zinc. It exists also, according to him, in metallic zinc, though in very small quantity.

Previous to the experiments of Stromeyer, a preparation of zinc from Silesia was thrown aside by the apothecaries for containing arsenic, because, when dissolved in acid, it was found by Roloff to give a yellow precipitate on the addition of sulphuretted hydrogen, which was considered by him to be orpiment. Roloff, however, in repeating his experiments, ascertained that this precipitate was not occasioned by arsenic, but by another metal, not then known.

Specimens of the Silesian oxide of zinc, and of the precipitate, were afterwards sent to Stromeyer, who ascertained that the phenomena presented by this particular oxide, were owing to the presence of the peculiar metal which he had discovered in the compound of zinc prepared at Salsgitter, and to which he had given the name of cadmium.

Cadmium is procured by dissolving the substances containing it in sulphuric acid, and passing a stream of sulphuretted hydrogen through the solution. The precipitate formed, after being well washed, must be dissolved in muriatic acid, and the excess of acid driven off by heat. What remains is dissolved in water, and carbonate of ammonia is added in excess, to dissolve the copper and zinc precipitated by the sulphuretted hydrogen. In this way carbonate of cadmium is obtained, the carbonic acid of which is expelled by heat. The oxide is then reduced by exposing it with charcoal to a high temperature. Cadmium is of a light whitish colour, inclining to grey, very nearly resembling that of tin. It possesses considerable brilliancy, and takes on a fine polish. It is of a compact texture, and possesses also considerable lustre. It is likewise very ductile, and may be beat into thin plates.

The specific gravity of cadmium at 62 is 8.604. After being hammered, its specific gravity is increased to 8 694.

Cadmium, when subjected to caloric, fuses, and on cooling, it crystallises in octahædrons. At a temperature not much exceeding that of the boiling point of mercury, it passes into vapour, which has no peculiar odour, and which condenses in small drops, exhibiting a crystalline structure.

By mere exposure to the air, cadmium does not undergo any change.

When heated in contact with atmospherical air, it takes fire, and forms a brownish yellow oxide.

Oxide of Cadmium. Cadmium has been made to unite with only one proportion of oxygen.

The oxide has a yellowish green colour, which, however, by exposure to heat, becomes yellow. If the application of the heat be long continued the oxide becomes brown. These changes in the colour are supposed to be owing to the difference in the cohesion of the body; for when they are dissolved by an acid, the same compounds are always formed.

The oxide of cadmium does not undergo any particular change by the application of heat to it. When kept at a white heat in a covered crucible for some time, it did not undergo fusion. When heated in contact with charcoal, it is reduced, the reduction taking place at about a red heat.

The oxide of cadmium is composed of

100 cadmium,
14.353 oxygen.

From this it is inferred that the equivalent number for the metal is 69.677, that of oxygen being 1.

Phosphuret of Cadmium. Cadmium combines with phosphorus, and forms a grey-coloured compound, which is very brittle, and has a slight metallic lustre. When put on burning coals, it emits a beautiful flame, and is converted into phosphate of cadmium. Muriatic acid decomposes it with the evolution of phosphuretted hydrogen.

Sulphuret of Cadmium. Cadmium unites with sulphur; the sulphuret is however easiest formed by heating together the oxide and sulphur. It has a yellow colour when cold, but when exposed to heat it first becomes brown, and then crimson. At a white heat it fuses, and on cooling crystallizes in transparent yellow plates. Sulphuret of cadmium is decomposed by strong muriatic acid, with the disengagement of sulphuretted hydrogen. It is composed of

100 cadmium,
28.172 sulphur.

It is recommended as a good pigment.

Chloride of Cadmium is obtained in rectangular prisms, which, when subjected to heat, sublime, and effloresce on exposure to the air. It is composed of

61.39 cadmium,
38.61 chlorine.

Iodide of Cadmium is obtained in hexaedral transparent colourless tables, which are decomposed at a strong heat, and part of the iodine escapes. It is not altered on exposure to the air, and is not soluble in water. It is composed of

100 cadmium,
227.43 iodine.

The oxide of cadmium unites with acids, and forms with these, salts, which are in general of a white colour. It is insoluble in the fixed alkalies. Ammonia, however, dissolves it. It is also soluble in carbonate of ammonia. Cadmium is acted on by nitric acid, nitric oxide being disengaged during the solution. It is also dissolved, though slowly, by sulphuric and muriatic acids, accompanied with the evolution of hydrogen.

The salts of cadmium are decomposed by the alkalies. By the addition of potassa or soda to the solution of the nitrate, the sulphate, or muriate, a precipitate of a white colour is thrown down, which is not soluble in an excess of alkali. The precipitate is supposed to be the yellow oxide, in combination with water, which gives it the white colour. By the addition of ammonia to these salts, the same precipitate is formed, but is dissolved on adding an excess of the alkali.

Sulphuretted hydrogen, and the hydro-sulphuret of an alkali, throw down a yellow precipitate, which, when dried, acquires an orange yellow colour, something similar to orpiment. The precipitate formed in this case is considered a hydro-sulphuret; it is recommended as a yellow pigment, for which, from its durability, it seems well adapted.

Prussiate of potassa, when added to a solution of a salt of cadmium, throws down a white precipitate. Cadmium is precipitated in the metallic state, from a solution of any of its salts by zinc, the precipitate putting on the dendritic form. On the contrary, when a piece of cadmium is put into a solution of a salt of gold, silver, copper, or lead, these metals are precipitated.

Nitrate of cadmium crystallizes in prisms, and is deliquescent. It is composed of

110 acid,
117.50 oxide.

Carbonate of Cadmium is insoluble in water. Its component parts are 100 acid,

292.88 oxide.

Phosphate of Cadmium is also insoluble. When exposed to a red heat it melts into a transparent glass. It is composed of 100 acid,

225.49 oxide.

Borate of Cadmium is little soluble. When dry it is composed of 27.88 acid,

72.12 oxide.

Sulphate of Cadmium is obtained in large rectangular transparent crystals, which are very soluble in water. It is efflorescent, and when exposed to a strong heat is decomposed, and forms a sub-sulphate. The sulphate is composed of 100 acid,

161.12 oxide.

Acetate of Cadmium is soluble and crystallizable.

Tartrate and Citrate of Cadmium are little soluble.

Oxalate of Cadmium is insoluble.

Cadmium unites with other metals, and forms alloys, which are brittle.

The alloy with copper has a slight tinge of yellow. By the application of a strong heat to it the cadmium is volatilized. It is composed of

100 copper,
84.2 cadmium.

When the cadmium does not exceed the one-hundredth part of the copper, the latter is rendered very brittle. As however the cadmium is expelled by the application of heat to the alloy of these metals, there is no danger of brass made with the substances which contain cadmium being injured by the presence of the latter metal.

The alloy with mercury. Cadmium combines with mercury with great facility, and forms a hard brittle alloy, fusible at 167°. It is composed of

100 mercury,
27.78 cadmium.

The alloy with platinum is composed of

100 platinum,
111.3 cadmium.

The alloy with cobalt is brittle, and not easily fused.

Wodanium.

Lampadius, when examining a mineral supposed to contain cobalt, discovered in it a new metal, to which he has given the name of wodanium. The mineral in which this was found has a metallic lustre, and a greyish colour: its specific gravity was 5.192.

Wodanium has a bronze yellow colour; it is malleable, and strongly attracted by the magnet. Its specific gravity is 11.47.

When exposed to the air it is not tarnished; when subjected to heat in contact with the air it is oxidated.

Nitric acid acts on wodanium; and forms a solution which affords colourless needle-formed crystals, which are very soluble in water. By the addition of ammonia to the solution of a salt of wodanium, a blue precipitate is thrown down. The alkaline phosphates and the arseniates do not afford any precipitate.

Prussiate of potassa throws down a pear-grey precipitate.

A piece of zinc, immersed in the solution of the muriate, precipitates a black metallic powder.

The infusion of nut-galls does not cause any change when added to a solution of a salt of wodanium.

Vestium, or Sirium.

According to Dr. Vest, there exists in the cobalt ore of Schladming, in Upper Steiermark, a peculiar metal, to which the name of Vestium has been given.

To procure this metal, the ore, after being freed from its impurities, was mixed with powdered glass, and fused; what remained was digested in nitric acid, and the arsenic which was dissolved was separated by the addition of acetate of lead and sulphuretted hydrogen. Carbonate of potassa was then added, which threw down the oxide of iron. By evaporating the filtered fluid, a flaky substance was separated, which was a salt of vestium. By the addition of potassa to the fluid after filtration, a precipitate fell, which was dissolved in sulphuric acid. To the solution, sulphate of potassa was added, and another portion of the flaky matter was deposited, mixed with a salt of nickel. These were separated in a great measure by washing. To obtain the salt of vestium pure, the matter deposited was mixed with sulphate of potassa, dissolved in water, and crystallized. What was obtained was boiled in a solution of carbonate of potassa, by which a precipitate was thrown down. This was dissolved in nitric acid, the solution was evaporated to dryness, and the residue, after being exposed to a red heat, was washed with cold muriatic acid, and then dissolved in that acid at a boiling temperature. By the addition of potassa to the solution, the oxide of vestium was precipitated free, as Dr. Vest imagines, from the other substances contained in the ore. By mixing the oxide with arsenic, and exposing it to heat, it was reduced, leaving a metallic button, which was brittle, and had a granular texture.

Oxide of vestium is soluble in nitric, sulphuric, muriatic, and acetic acids. The salts formed are soluble in water. The solutions on evaporation afford crystals, which, when acted on by water, deposit the oxide.

Sulphuretted hydrogen, when added to a solution of a salt of vestium, throws down a reddish-brown precipitate, provided there is not an excess of acid present; if there be a superabundance of acid, no change takes place on the addition of sulphuretted hydrogen.

The alkalies afford precipitates with the solutions of the salts of vestium; that thrown down by ammonia is soluble in an excess of the alkali. The carbonate of potassa and of soda precipitate a carbonate of vestium. Carbonate of ammonia separates a white powder from the muriate, but scarcely effects any change on the sulphate.

Sub-borate of soda does not afford any precipitate with a diluted solution of a salt of vestium.

The phosphate, oxalate, and prussiate of the alkalies, throw down white precipitates.

Lime-water, and the infusion of nut-galls, also precipitate a white powder. The same occurs when a piece of zinc is immersed in a solution of a salt of vestium.

Such are the properties ascribed to vestium. The existence of this as a distinct metal has, however, been called in question by Dr. Wollaston, and Mr. Farraday, chemical assistant in the Royal Institution of London, to whom a small piece of the metal called vestium was sent for examination.

Mr. Farraday dissolved the metal in warm nitric acid. The solution, on the addition of nitrate of baryta, yielded a precipitate of sulphate of baryta. Ammonia added to the solution, afforded oxide of iron The fluid, after filtration, was of a bluish colour, and afforded, with prussiate potassa, a white precipitate. These experiments indicate the presence of sulphur, iron, and nickel; the first of which was acidified by the nitric acid, and yielded the precipitate of sulphate of baryta.

By the action of nitric acid on the metal, a blackish substance was left undissolved, which, according to the experiments of Mr. Farraday, contained an arseniate, for when dissolved in an acid, it gave a yellow precipitate with nitrate of silver, and a greenish one with the sulphate of copper.

With the above results, the experiments of Dr. Wollaston agree. These chemists, therefore, assert, that the substance considered by Dr. Vest as a new metal, is merely a combination of sulphur, iron, nickel, and arsenic, and also cobalt, which was indicated in their experiments.

The principal circumstance that led Dr. Vest to pronounce the substance which he obtained from the cobalt ore of Schladming, a new metal, was its not being precipitated from its solution by sulphuretted hydrogen, when an excess of acid was present, but being thrown down when the solution was neutral. This, however, is the case with nickel.

If a new metal, therefore, do exist in the ore of Schladming, Dr. Vest does not seem to have procured it free from the other bodies contained in the ore, nickel, arsenic, and cobalt.

METAPHYSICS.

Metaphysics have been called the *First Philosophy*, or the *Science of Sciences*, as their object is to explain the principles and causes of all things existing, and to supply the defects of inferior sciences, which do not demonstrate, or sufficiently explain, their principles. Metaphysics, says Lord Monboddo, consider the τα οντα η οντα; that is, things, not as the terms of propositions or syllogisms, but by themselves, and as existing in nature, and not as the subject of any particular science, though they be the principles of all sciences, and of all things existing in the universe.

Some have supposed, that metaphysics have derived their name merely from the circumstance of their being placed after the physics of Aristotle, and have laughed at the fancy of giving a name to a science, from its accidental position among the writings of a certain author. The supposition is unfounded, and of course the ridicule misplaced. When Aristotle inscribed his books which treat of the principles of things, των μετα τα φυσικα, it is evident that he had one of two things in view: he must either have meant that the subjects treated of ought, in the order of study, to come after physical researches; or that they were of a higher character, and required higher faculties to comprehend them. In either of these acceptations, the term metaphysics is peculiarly appropriate; and were we to admit that it was imposed originally by the Aristotelians through ignorance, and without any authority from their master, we would certainly say, that it is the most fortunate coincidence of an accidental name with the true nature of the science to be found in the history of scientific nomenclature.

Having vindicated the name from the charge of a spurious origin, we fear that we shall have still greater difficulty in rescuing the science itself from the opprobrium and ridicule into which it has fallen in the estimation of the present superficial generation. We grant that the ancient nomenclature of the science is sufficiently repulsive; and we are not surprized that the readers of reviews, magazines, and novels, should shrink with horror at the following enumeration of heads into which the schoolmen divided the subject: 1. Ontology; 2 Cosmology; 3. Anthroposophy; 4. Psychology; 5. Pneumatology; 6. Metaphysical Theology. This division was unnecessary and useless; it, for the most part, only tended to create distinctions where there was no real difference, and to render a science, which ought to have been explanatory of every other, the most intricate, perplexing, and uncertain; and we should have hailed with pleasure that independence of thinking, which, despising antiquated names, and unauthorised divisions, endeavoured to extend the boundaries of genuine science.

But the spirit of the ancient metaphysicians has not been expelled by such means as these; it has not, like the demonology of the dark ages, yielded to the light of superior knowledge; it has been driven out by fiends more fell and more foul than itself, by ignorance, indolence, and aversion to solid knowledge. Metaphysics are not the only science proscribed by the reigning taste in Great Britain; every thing that has the appearance of profound discussion, if it be connected with mind or with morals, is thrown aside with disgust; and nothing can obtain so much as an examination, if it is not connected with palpable science, or with that vitiated taste which feeds for ever, without being satisfied, on the fungous productions of superficial knowledge. What Johnston said sarcastically of the literature of Scotland. seems to be in a fair way of being realized as to the whole of Great Britain: it will soon be like a city in a siege, where every man has a ration of food, but no one gets a bellyful.

In such circumstances, we cannot expect much attention to be paid to metaphysics, when the subject both labours under a bad name, and requires too much expence of thought for the present frivolous taste of the age. "It is curious to remark," says an eloquent defender of metaphysical science,* "the strange notions which men, who are quite ignorant of its nature, have formed of the *first philosophy*." There are some who seem seriously to believe, that this science serves only to darken and bewilder the understanding; while others suppose, that it consists in the babbling of a pedantic jargon, which constituted the barbarous language of the scholastic learning. If a perplexed reasoner puzzle himself and his audience, we are almost sure to hear his metaphysical subtlety reproved or lamented; and he, upon his part, seldom fails to ascribe the confusion of his ideas to the obscure nature of all speculative doctrines. If a pert rhetorician get entangled in his own sophistries, he is ever ready to accuse himself of having too much of the very logic which he wants. There is not a mere tyro in literature, who has blundered round the meaning of a chapter in Plato, but is content to mistake himself for a philosopher. A sciolist cannot set up for an Atheist, without first hailing himself a metaphysician; while an ignorant dogmatist no sooner finds himself embarrassed with a doubt, than he seeks to avenge his offended vanity, by representing all metaphysical inquiries as idle or mischievous. Thus the noblest of the sciences is mistaken and vilified by the folly of some, and by the prejudices of others; by the impertinent pretensions of a few, who could never understand it, and by the unjustifiable censures of many, who have never given it a fair and candid examination. He, however, who has been accustomed to meditate on the principles of things, the springs of action, the foundations of political government, the sources of moral law, the nature of the passions, the influence of habit and association, the formation of character and temper, the faculties of the soul, and the philosophy of mind, will not be persuaded that these things are unworthy of his patient attention, because presumptuous writers have abused the liberty of investigation, or because dull ones have found it to be unavailing. He knows that metaphysics do not exclude other learning; that, on the contrary, they blend themselves with all the sciences. He feels the love of truth to grow strong with the search

* Sir William Drummond.

of it. He confesses the very bounded powers of the human understanding, while he contemplates the immensity of nature, and the majesty of God; but he thinks that his researches may contribute to enlarge and correct his notions, that they may teach him how to reason with precision, and that they may instruct him in the knowledge of himself. His time, he believes, is seldom employed to greater advantage, than when he considers what may be the nature of his intellectual being, examines the extent of his moral duties, investigates the sources of happiness, and demonstrates the means by which it may be more generally diffused.

We readily grant, that metaphysics have often been grossly abused; they have been disgraced by the uncouth and fantastic dress in which they have been exhibited, or by the perverted purposes to which they have been directed; they have been rendered contemptible by the quibbling of the schoolmen, and by the sophistry and scepticism of Hobbes, Spinosa, and Hume; and we may justly despair of redeeming their credit with those who argue against the general use of any thing from its occasional abuse. Such persons might argue against the benefit of the solar heat, because it is often the cause of pestilence and disease. But we are firmly convinced, that in proportion as intellectual or metaphysical studies are neglected, taste will degenerate, and the general energy of mind will be impaired. That man is a genuine metaphysician, who dives into the nature of things, who methodizes seemingly anomalous facts, and reduces to simple and perspicuous rules, those appearances which present to others nothing but a mass of disjointed and incongruous materials: the man who does this is a benefactor of the human species, and his memory will be honoured as such, while the names of the grovelling herd, who laughed at his pursuits, will be covered with sudden and everlasting oblivion.

How would those who pretend to despise metaphysics have been able to stand before the acuteness of the celebrated sceptics, whose names have been already mentioned? It was necessary that such men as Locke and Berkeley should oppose the dangerous doctrines of Hobbes and Spinosa, on politics, morals, and religion; and that such men as Reid, Campbell, and Stewart, should encounter the dangerous sophistry of Hume. If it should be said, that an instrument so convertible to the best or worst of purposes, had better be kept out of the hands of the generality of men, this is as much as to say, that the power of reason should never be exercised, because it is equally the means of disseminating truth, and of giving currency to error. If any evil consequences have ever resulted from metaphysical discussions, it is only a farther illustration of what has generally been regarded as an axiom, that the corruption of the best things produces the worst effects. Whatever has much power to do good must, if abused, have much power to do mischief; and if metaphysics have occasionally been employed to unhinge belief, or to unsettle the foundations of virtue, it should be remembered, that we derive the means of cure from the same source, and employ the same instruments, but differently handled and applied, to erect the temples of truth, happiness, and virtue.

If mankind knew but where to stop in their researches, metaphysics would appear the most useful, as well as the most sublime science that ever engaged the faculties of the human mind. But they are often brought into discredit, not through any inherent defect in themselves, but from the restless and insatiable desire of the mind to comprehend all mysteries and all knowledge. As this attempt must necessarily prove unsuccessful, we may expect to see the blame laid on the science, which has been employed as the means of investigation. Let man be blamed for attempting impossibilities; but let the science be respected, which will carry him as far as he can go with pleasure and with safety.

Let all the absurdities, then, that have ever proceeded from the brain of a bewildered or sceptical metaphysician, be mustered up to sustain the arraignment against the utility of ontological science, the whole host must instantly give way, before the immortal works which have put them down, by the judicious application of the same principles which less sober or less virtuous men had abused. Is it not in the highest degree ungenerous, then, to remember only the evils which the abuse of the science has produced, without acknowledging the benefits which it has conferred, and feeling grateful for having laid the sure foundations of taste, reasoning, and knowledge? No man will doubt the utility of metaphysical studies, who knows any thing about them, and who is disposed to conduct his researches with that coolness, and philosophic caution, which is necessary to ensure success in any investigation. Let no one, then, be deterred from entering on this study by the outcries of ignorance or prejudice; or by the misrepresentations of those who rail at what they do not understand. *Sicut canes ignotos semper allatrant.* Let those abstain from metaphysics who think that they never ought to grapple with any thing that is profound: let those avoid them, who think that there is no knowledge but what is apprehended by the outward senses: but let those continue to maintain the honour of the science, who wish to explore the recesses and resources of their own minds, who seek to be acquainted with the nature and essential qualities of things, or who wish to know any thing of substance, its attributes, and its adjuncts.

> *Unde anima, atque animi constet natura, videndum,*
> *Qua fiant ratione et qua vi quæque gerantur*
> *In terris.*

But we admit that metaphysics have not only been abused by faulty investigations and unwarranted assumptions, they have also frequently been brought into disrepute by the ridiculous pretensions of some of their advocates. Were we to give credit to Mr. Harris or Lord Monboddo, we should scarcely believe that a man could be confident of the number of his own fingers, unless he were instructed in the metaphysics of Aristotle. What can be more puerile than the observations of the Scottish senator, when he says, that "a mechanic who applies a foot or a yard to the length of two bodies, and finds that both agree exactly to that measure, and are neither longer nor shorter, can give no reason why he believes the bodies to be of equal length, not knowing the axiom of Euclid, that two things which are equal to a third thing, are equal to one another?" (*Ancient Metaphysics*, vol. v p. 154.) Is it not evident, that the mechanic knew the axiom as well as Euclid, and could give just as good an account of it? When he knows the fact he knows the axiom; and he knows, with infallible certainty, that what he has observed in one measurement is applicable to all similar ones; he, therefore, instantly and intuitively adopts the fact as a general principle of knowledge.

We do not know that our readers would thank us, were we to attempt to give a complete system of metaphysics. But, in truth, notwithstanding all that has been done, the attempt is too vast for any individual. Many have elucidated with peculiar success, particular branches of metaphysical science; and they who have attempted more, have, in general, only demonstrated the deficiency of their qualifications, and the futility of their labours. We doubt not, therefore, that our prudence will be approved in declining an undertaking in which so many have failed, though gifted with respectable talents, and armed with high pretensions. We have given in the article Logic, under the head Pneumatology, (which we have considered as embracing Psychology, the most interesting branch of metaphysics,) an account of the origin of our knowledge, of the way in which the mind receives its impressions, of the methods which it employs to communicate its ideas, and of the various circumstances which tend to modify its conceptions. These topics, which might with propriety have fallen under the present article, being already discussed, shall not be repeated. In the article Moral Philosophy also, will be found some important discussions respecting the influence of the will and the affections, and the liberty or necessity of human actions. It is therefore unnecessary to dwell on these subjects here. We shall merely attempt a rapid sketch of what has been done in metaphysics; and this, rather with a view to point out to our readers the subjects and scope of the science, than to require their acquiescence in the doctrines and speculations which have been so elaborately detailed.

Aristotle stands at the head of metaphysicians in point of priority of time, and probably also in point of pre-eminence of intellect. What he fails to elucidate, he envelopes in such a veil of mysticism and perplexing phraseology, that it is scarcely possible to divine his meaning, much less to correct his errors. This circumstance has misled many of his followers and admirers, who, trusting to his infallibility, and convinced that every thing he says must have a profound, if it has not an obvious meaning, have laboured with most indefatigable industry to elucidate his inscrutable researches, and to persuade the world that they contain the substance and essence of all knowledge. The very obscurity which hangs over the writings of Aristotle has tended to increase his fame, and to exalt the reputation of his genius. For ingenious men finding many passages of transcendent excellence in the writings of Aristotle, and many most profound and sublime speculations, have given him credit for a species of omniscience in every kind of science; and whenever any thing occurs which is not very obvious, they uniformly ascribe the difficulty to the profundity of the author's views, and not to the obscurity of his conceptions. Their own minds being at the same time preoccupied by some favourite metaphysical notions, they eagerly watch for any hint in the writings of their idol, which may serve to confirm their own opinion. These hints they may easily find. By disjoining one passage from another, or by connecting remote passages according to their own conceptions, they may make Aristotle speak any language, and lend his suffrage to any set of philosophical opinions. Those passages which are most obscure, will generally answer the purpose best. As they cannot be decidedly claimed as supporting an obvious doctrine, we are ready to feel thankful to any who can attach to them a rational meaning; and we generally find it as easy to assent to it, as to establish a different or opposite signification.

It is, however, but fair to remark, that Aristotle is perhaps scarcely chargeable with one half of the obscurity which now envelopes his writings; and probably also, he is not entitled to full credit for many of the most useful doctrines contained in them. We allude to the vicissitudes which his writings have undergone, and to the mangled and mutilated state in which many of them were found. After having lain in a subterraneous cavern in the town of Scepsis, for 130 years, they were brought to light, and sold to Apellico, a Teian, who, with injudicious industry, supplied from his own conjectures such passages as had become illegible. It is impossible to ascertain the extent of these supplementary emendations, which, in all probability, savoured more of the opinions of the transcriber than of the spirit of Aristotle. But this was not the last ordeal which they underwent. It is well known that they were transferred to Rome by Sylla, after the taking of Athens. Here Tyrannion, a grammarian, having obtained permission to make use of the manuscripts, employed ignorant amanuenses to take copies of them, which he suffered to pass out of his hands without proper correction. These errors have been continued by succeeding commentators and transcribers, who have often introduced into the text conjectural emendations and variations. All ancient writings are liable, in a greater or less degree, to such accidents; but none so much as those which record philosophical doctrines; for here, if there is a possibility of perversion, the commentator or transcriber will endeavour to make the text subservient to his preconceived opinions.

At present, we are only concerned with the metaphysics of Aristotle; and of these we shall give as concise an account as possible. According to him, the fundamental principle of ontology is, that it is impossible that the same thing should be, and not be, in the same subject, at the same time, and in the same respect. To this universal principle all demonstration may be reduced. Being may be reduced into the ten categories, or predicaments, which are, 1. *Substance*, which is either primary, and can neither be predicated of, nor inherent in, any other subject: or secondary, which subsists in primary substances, as *genera* or *species*. 2. *Quantity*, continued or discrete; which has no contrary, and denominates things equal or unequal. 3. *Relation*, expressing the manner in which one thing is affected towards another. 4. *Quality*, by which a thing is said to be such as it is. 5. *Action*, signifying the motion of the agent. 6. *Passion*, signifying the state of the patient. 7. *When*, denoting time. 8. *Where*, denoting place. 9. *Situation*, expressing the external circumstance of local relation. 10. *Habit*, expressing the external circumstance of being habited.

Being is either notional or real; notional, as it is conceived in the mind; real, as it exists in nature. Notional *being* is either true or false; true, when it corresponds to the real nature of things; false, when the conception and the reality differ from each other. In the knowledge of things immutable the intellect cannot be deceived; mistake and error can only arise concerning contingent and variable objects.

Aristotle's notions respecting the first mover were, in some respects, sublime; in others confused and unintelligible. He admitted an original principle of motion, which he said must be simple pure energy, void of matter, eternal, immutable. The essence of the first mover is different from that of corporeal substances, indivisible, because unity is perfect; immutable, because nothing can change itself; and eternal, because motion itself is eternal: (this is a gratuitous assumption.) This power is an incorporeal intelligence; happy in the contemplation of himself; the first cause of all motion; and, in fine, the Being of Beings, or God.

As to the soul, he said that it was the principle of action in an organized body possessing life potentially. It does not move itself, for whatever moves is moved by some other moving power. It is not a rare body composed of elements; for then it would not have perception, more than the elements which compose it. The soul has three faculties, the *nutritive*, the *sensitive*, and the *rational;* the superior comprehending the inferior potentially. The nutritive faculty is that by which life is produced and preserved. The sensitive is that by which we perceive and feel; it does not perceive itself, nor its organs, but some external object, through the intervention of its organs, which are adapted to produce the sensations of sight, hearing, smell, taste, and touch. The senses receive sensible species or forms without matter, as wax receives the impression of a seal without receiving any part of its substance, the external senses perceive objects, but it is the common or internal sense which observes their difference.

He defined the mind to be the principle by which we live, perceive, and understand. When he attempted to form an abstract conception of this principle, he saw that there must be some substance which enjoys such *perfection*, as to be capable of performing this function: and in defining this substance, he made use of a term, which his followers suppose to express some very profound and recondite meaning: he called it *Entelecheia*, that is, *perfection*, or *perfect energy*. This word was conceived to be so very mysterious, that Hermolaus Barbarus, who translated the *Rhetoric*, and other pieces of Aristotle, is said to have implored the assistance of a divinity to enable him to understand its meaning: had he obtained this favour, it is probable that he would have been farther advanced than Aristotle who framed it. It was differently understood by different authors, according as it suited their particular views, and is thus explained by Leibnitz to accommodate his leading hypothesis: *Nomen Entelechiarum imponi possit omnibus substantiis simplicibus seu monadibus creatis.*

Aristotle's metaphysical notions respecting matter were very singular, and we believe we may say incomprehensible. This, of course, is not admitted by adepts, who maintain that he has given us the only intelligible views on the subject. We shall allow the master and the scholars to explain their own ideas Matter, according to Aristotle, is either πρωτη or προσεχης; that is, *primary* or *proximate*. Thus, iron and wood are not of the same proximate matter; but their primary or elementary matter is the same. If the primary matter did not exist, neither could the proximate or immediate. The primary matter is neither earth, nor air, nor fire, nor water; it is neither hot, nor cold, nor dry, nor moist, nor solid, nor extended. It is the universal element, but can never become objective to sense. Spinoza, who was an acute sophist, and a deep read, though we cannot think a profound metaphysician, availed himself of these sublimated, or rather incomprehensible notions of matter, to establish his system of universal materialism, by which he makes Deity himself material. The French philosophists, during the revolutionary phrenzy, went still farther than this; and one of them had the insanity to announce, that he hoped soon to be able to ascertain the particular form of crystallization which constituted Deity! Spinoza, like Aristotle, contended that primary matter, or substance as he calls it, is something completely distinct from any of its modifications, in order to elude the objections which had been urged against his system, from the mutability and divisibility of matter. For it was said with justice, that if Deity was material, the self-existent and eternal principle which Spinoza admitted must be mutable and divisible, which is absurd. Sir William Drummond, in his academical questions, has given a pretty full exposition of the physical and moral system of Spinoza, and has given every advantage to the interlocutor who supports it, without adducing any counterbalancing refutation.

His design in this was singular; for he is any thing but a Spinozist. But as his object is to explode the existence of matter, independent of the perceptions of mind, he seems to wish to terrify his readers into his doctrine, by stating the dangerous consequences which result from admitting the independent existence of matter. The experiment is a little dangerous; for were there no medium between Spinozism and idealism, a good part of mankind might be puzzled how to form a decision. But there is a medium; and whatever difficulties may attend the conception of matter as existing independent of our perceptions, it certainly involves no impossibility.

If our readers find any difficulty in forming a conception of matter abstracted from all its qualities, they shall have the benefit of Mr. Harris's illustration: "We gain a glimpse of it by abstraction, when we say that the first matter is not the lineaments and complexion which make the beautiful face; nor yet the flesh and blood which make those lineaments and that complexion; nor yet the liquid and solid aliments which make that flesh and blood; nor yet the simple bodies of earth and water which make those various aliments; but something which, being below all these, and supporting them all, is yet different from them all, and essential to their existence."

But our elegant author is not content with giving us a glimpse of this subtile and evanescent substance: "We obtain a sight of it, he observes, when we say, that as is the brass to the statue, the marble to the pillar, the timber to the ship, or any one secondary matter to any one peculiar form, so is the first and original matter to all forms in general."

This certainly seems to be pushing matter to the very verge of existence; and, therefore, Sir William Drummond, a keen immaterialist, observes, that we had better pause before we break the bubble of the ideal philosophy, lest it be all that is left to save us from utter annihilation.

The metaphysics of Aristotle formed the text book on these subjects to Europe and the world, for many centuries. The Arabians were as great adepts as the monks of the dark ages. To be able to comprehend and to wield the *Organum* of Aristotle, was considered as the highest attainment in knowledge, and the most desirable accomplishment in literature. It was reckoned presumptuous, and almost heretical, to call his authority in question. Of this we have a remarkable proof in the fate of Peter Ramus, an intrepid impugner of the Aristotelian philosophy. His bold attacks on a system which had been admired for so many ages, gave great offence. His antagonists, however, attacked him at first only with arguments. But finding him refractory, or rather too strong for them, they proceeded to harsher measures. He was accused of an attempt to subvert both religion and philosophy; and though he challenged his opponents to a public disputation, he could not obtain an impartial hearing; and was prohibited by Francis I. from writing or teaching philosophy. This sentence was afterwards reversed by Henry II. and Ramus was appointed regius professor of eloquence and philosophy, and afterwards of mathematics. His enemies, however, became more virulent than ever, when it was found that Ramus favoured the principles of the Reformation. He was obliged to leave France; and after travelling three years in Germany, to visit the principal universities, he unfortunately resolved to return to Paris, where he lost his life by the hand of a hired assassin in the infamous massacre of St. Bartholomew's eve.

But it was the reformation in religion which completed the overthrow of the Aristotelian philosophy. Luther had been early instructed in the Peripatetic doctrines, and in all the subtleties of the scholastic philosophy as taught by Thomas Aquinas, Duns Scotus, and others; and had attached himself to the party of the Nominalists in the dispute about universals. When, however, his eyes were opened to see the errors of the Romish doctrines, he began to question the validity of the principles on which these errors had chiefly rested for support. The result was a thorough conviction of the inutility of the Aristotelian method, and an indignant and contumelious contempt of its quibbles and false refinements. "What does it contribute, says he, towards the knowledge of things, to be perpetually trifling and cavilling in language conceived and prescribed by Aristotle concerning matter, form, motion, and time?" In Luther's ardent temperament, the heat of controversy might easily carry him unwarranted lengths in expressing his contempt for Aristotle's doctrines. He was no enemy to sound philosophy, but he was anxious to free the world from the yoke of authority, both in philosophy and religion.

The defection being thus begun, the revolt soon became general. The method of induction recommended by the powerful genius of Bacon, completely undermined the authority of Aristotle in physical researches; and Descartes soon began to think for himself, and to devise a new method of studying the philosophy of the human mind. The first thing he did was, to dismiss from his mind all reverence for any preceding doctrines and opinions. He went farther still, for he attempted to discard all previous belief which was not established on demonstration. The first point, then, was to ascertain the reality of his own existence; and we should think it would not have been very easy to have done this to the satisfaction of a man who seriously doubted of it. He satisfied himself on this point, however, by reflecting, that what thinks, must exist. *Repugnat enim ut putemus id quod cogitat eo ipso tempore quo cogitat non existere. Ac proinde hæc cognitio, ego cogito, ergo sum, est omnium prima et certissima, quæ cuilibet ordine philosophanti occurrat.* Having thus satisfied himself of his own existence, he next proceeds to examine what evidence he has for the existence of any other object or substance besides himself. He had been accustomed to believe in an external world; on reflection, however, he found that all he knew of that world was in himself; and therefore he was entitled to doubt the reality of its existence; because some superior being might have desired to deceive him. But he is sure he cannot be deceived as to the axiom by which he proves his own existence. *Fallat me quisquis potest, nunquam tamen efficiet ut nihil sim quamdiu me aliquid esse cogitabo.* After the utmost reflection, he finds that he had believed the existence of external objects only *cæco aliquo impulsu*; and he now proceeds to search for arguments. And, first, he satisfies himself that there is a God; for he can form a clear idea of his perfections; perfections which he knows do not exist in himself; but since he entertains the idea of them, there must be an archetype of that idea; and this carries him at once to the Supreme Being, as possessing all the attributes which he had conceived of him.

His reasoning is ingenious, and we shall give it in his own words: "Quia Dei, sive entis summi ideam habemus in nobis, jure possumus examinare, a quanam causa illam habeamus: tantamque in ea immensitatem inveniemus, ut plane ex eo simus certi, non posse illam nobis fuisse inditam, nisi a re, in qua sit revera omnium perfectionum complementum, hoc est, nisi a Deo realiter existente. Est enim lumine naturali notissimum, non modo a nihilo nihil fieri; nec id quod est perfectius ab eo quod est minus perfectum, ut a causa efficiente et totali produci; sed neque etiam in nobis ideam sive imaginem ullius rei esse posse, cujus non alicubi, sive in nobis ipsis, sive extra nos, archetypus aliquis omnes ejus perfectiones reipsa continens, existat. Et quia summas illas perfectiones, quarum ideam habemus, nullo modo in nobis reperimus, ex hoc ipso recte concludimus eas in aliquo a nobis diverso, nempe in deo, esse; vel certe aliquando fuisse, ex quo evidentissime sequitur, ipsas adhuc esse." *Princip. Philosoph. pars prima.*

This is perhaps as good an *a priori* argument for the existence of a God as Dr. Clarke's; and indeed, in some respects, it is not unlike it. Dr. Clarke seems to have borrowed his argument from the following passage in Newton's *Principia*: "Eternus est et infinitus, omnipotens, et omnisciens; id est durat ab eterno in eternum, et adest ab infinito in infinitum. Non est eternitas et infinitas, sed eternus et infinitus; non est duratio et spatium, sed durat et adest. Durat semper, et adest ubique; et existendo semper et ubique durationem et spatium constituit." We would have willingly travelled out of our way, at any time, to exhibit such a sublime specimen of metaphysical theology. Dr. Clarke has made the following use of it: Space and time, he observes, are only abstract conceptions of an immensity and eternity, which force themselves on our belief; and as immensity and eternity are not substances, they must be the attributes of a Being who is necessarily immense and eternal. We shall by and by examine the foundation of this argument.

Descartes having satisfied himself as to the existence of a God, no longer hesitates in acknowledging the reality of an external world; for he concludes that the God whom he serves will not deceive him; as a desire to deceive can only proceed from malice, or fear, or weakness; none of which qualities can ever apply to God.

Descartes adopted the common theory respecting perception. Till his day, and long after it, nobody doubted that certain images were propagated from bodies, in some unaccountable manner, which produced ideas in the mind. Aristotle, as we have already stated, illustrates this, by saying that the senses receive sensible species, or forms, without matter, as wax receives the impression of a seal, without receiving any part of the substance. The received maxim among the Peripatetics, and we do not see how it can be disputed, is, that nothing can act where it is not; and therefore, if matter be different from mind, there must be some medium interposed to bring them, as it were, into contact. This opinion has given rise to a variety of theories half metaphysical, half physiological, such as that of animal spirits, or as the vibrations of Hartley, and the like, with a view to explain the way in which the immaterial substance of the soul is acted upon by external objects. We conceive all such attempts to be futile; nor can we form any conception of contact between a material and an immaterial substance; or of the manner in which body acts on spirit, or this on material substances. An author of some celebrity,* has advanced a very extraordinary hypothesis to explain this mysterious subject; we shall give a part of it in his own words, to caution our readers against the danger of theorizing: "Were I permitted to conjecture in a matter where nothing better than conjecture can be had, I should suppose spirit naturally penetrable, but capable of rendering itself solid upon occasion, with respect to particular bodies, and that hereon our activity depends. I have formerly given my reasons for imagining, that the force wherewith we move our limbs, is derived from the animal circulation rushing into the muscles through certain nerves, and that the orifices of these nerves are provided with stoppers, which the mind draws up at pleasure to give the animal spirits admittance; now what should hinder our conceiving these stoppers pushed up by little hairs, or fibres, whose other ends lie within our spiritual part,† which by its natural penetrability, admits them into the space where it resides? But, upon the mind rendering itself solid with respect to any particular fibre, it is driven forward, thereby lifts up the stopper, and opens the passage into the nerves; until volition, forbearing to act, the penetrability returns—the fibre, no longer pressed, falls back to its former station, the stopper following, closes the passage, and muscular motion ceases."

The author proceeds in the same style; but we have given enough to exhibit a complete specimen of metaphysical absurdity, or rather of the danger which must always attend physiologico-metaphysical speculations.

Locke is by far the most celebrated metaphysician in modern times. There is a perspicuity and good sense apparent in his writings, which insures the attention and good will of the reader. He carefully banished the pedantic phraseology of the schools; and the world was astonished that subjects so profound should be rendered so simple. Even yet he is scarcely considered by some as a metaphysician, solely, we believe, because he employed the language of common life and common sense, in illustrating some of the profoundest points in ontology and psychology. Formerly none but the initiated dared to approach these subjects. They were discussed in a peculiar language, which was as remote from the common conceptions of mankind, and as unintelligible to common understandings, as the signs of free-masonry are to the uninitiated. Socrates was said to have brought philosophy down from heaven: and we may at least say of Locke, that he has brought metaphysics down from the clouds, and planted them in a congenial soil, and reared them with proper culture on the surface of this earth. Perhaps no one ever accomplished so much on such a subject, with fewer errors, and fewer marks of failure. In the article logic, we have pointed out what we conceive to be deficiencies or mistakes in his reasoning;—but we shall have conveyed to our readers an impression very different from our real feelings, if they imagine that we do not entertain the very highest reverence for the genius of Locke, and the highest gratitude for the important services which he has performed, in rendering easy and attractive the science of metaphysics and the study of the human mind.

Descartes had said that the Peripatetic philosophers resembled blind persons, who, in order to equalize the combat with persons who had the use of their eyes, endeavoured to draw them into a dark cavern, where vision could be of no use to them. It is impossible not to admit the justice of the remark, for, if ever there were any who darkened counsel by words without knowledge, this charge may be applied to the schoolmen who adopted the philosophy of Aristotle. No small part of the merit of Locke consisted in sweeping away this useless rubbish, and in teaching mankind to define their ideas and conceptions before they attempted to reason about them.

We are extremely sorry that an attempt has been made in modern times to veil philosophy in her ancient mystery, with a view to exclude her from the profane eyes of the vulgar. This attempt consists not in reviving the phraseology of the Peripatetic school, but in the invention of a set of new terms equally incomprehensible, and equally susceptible of ambiguity and misconception. The author who has made this attempt is Kant, the founder of the *Critical and Transcendental Philosophy*, as it is called in Germany. We have never been fortunate enough to meet with any who pretended to comprehend his system; and for ourselves, we have never yet attempted it. We will be

* Tucker.

† There is a curious coincidence between this wild notion and one advanced by M. Formey, to account for the phenomenon of dreaming. He supposes, like Hartley, that sensation is carried on entirely by means of *vibrations*, which are communicated through the nerves, from the first point of contact till they reach the farthest extremities, which are *dipped* in a spiritual fluid. It is worthy of remark, that this Essay of Formey's is published in the Transactions of the Royal Academy of Sciences and Belles Lettres at Berlin in the year 1746, three years before the appearance of Hartley's Observations on Man. This author, then, has anticipated both Hartley and Tucker. The coincidence is curious; and we should be inclined to suspect them of plagiarism, had the thought been worth stealing. Formey's words are, "Les emanations de ces corps, ou leur parties même heurtants nos nerfs, les ebraolent à la surface de notre corps, et comme lorsqu'on pince une corde tendue, dans quelque endroit que ce soit, toute la corde tremousse; de même, le nerf est ebranlé d'un bout à l'autre, et l'ebranlement de l'extremité interieure est fidelement suivi, et comme accompagné, tant cela fait promtement, de la sensation qui y repond." We cannot help thinking the coincidence between this doctrine and Hartley's too striking to be accidental. Now for Tucker's penetrable spiritual substance: "On con oit de plus aisement que cette extremité interieure est la plus facile à ebranler, parce que les ramifications daos lesquelles elle se termine sont d'une extreme tenuité, et qu'elles sont placées à la source même de ce fluide spiritueux, qui les arrose, les penetre, y court, y serpente, et doit avoir une toute autre activité, que lorsqu'il à fait le long chemin qui le conduit à la surface du corps."

excused for this confession of our ignorance, after the following declaration from Mr. Stewart. "As to Kant's own works, I must fairly acknowledge, that, although I have frequently attempted to read them in the Latin edition printed at Leipsic, I have always been forced to abandon the undertaking in despair, partly from the scholastic barbarism of the style, and partly from my utter inability to unriddle the author's meaning. Wherever I have happened to obtain a momentary glimpse of light, I have derived it, not from Kant himself, but from my previous acquaintance with those opinions of Leibnitz, Berkeley, Hume, Reid, and others, which he has endeavoured to appropriate to himself under the deep disguise of his new phraseology."* This mode of philosophizing deserves to be reprobated and exploded; and we sincerely hope that the German adepts will never be able to make a system of mysticism popular in any country which has been imbued with the philosophy of Locke†.

For some account of the leading principles of Locke's system, and some strictures upon them, see the article Logic. At present, we mean merely to advert to the revolution which his opinions have produced in the philosophy of the human mind; and to the very singular and opposite conclusions to which they have been made subservient. For, on the one hand, they gave rise to the system of Berkeley, Hume, and other idealists, who deny the separate existence of matter, and hold, that what we call by that name is only a modification of thought; whilst, on the other hand, they have given birth, particularly on the Continent, to the material system of Diderot and others, who maintain that mind is only a more refined species of material substance.

It may appear strange that such opposite conclusions should arise out of the same system; but it must appear stranger still, that they are both legitimately deduced from it. That is to say, that Locke, by not sufficiently guarding some of his principles, has afforded room for their being applied or perverted in both these ways. He himself never intended to teach any such doctrines as those which succeeding philosophers and sceptics have deduced from his opinions.

The most celebrated of these systems is that of Berkeley; and we have no hesitation in saying, that it is the most difficult to refute by reasoning. It not only denies the existence of the material world, but affirms that the existence of matter is impossible. Talking of the qualities of matter, Locke had said, that "the ideas of *primary qualities* of bodies are resemblances of them, and their patterns do really exist in the bodies themselves; but the ideas produced in us by these *secondary qualities* have no resemblance of them at all. There is nothing like our ideas existing in the bodies themselves. They are in bodies we denominate from them only a power to produce those sensations in us; and what is sweet, blue, or warm in *idea*, is but the certain bulk, figure, and motion of the insensible parts in the bodies themselves which we call so."

On these data Berkeley builds his system. "They who assert," says he, "that figure, motion, and the rest of the primary or original qualities, do exist without the mind in unthinking substances, do at the same time acknowledge that colours, sounds, heat, cold, and such like secondary qualities, do not; which, they tell us, are sensations existing in the mind alone, that depend on and are occasioned by the different size, texture, and motion of the minute particles of matter. This they take for an undoubted truth, which they can demonstrate beyond all exception. Now, if it be certain that those original qualities are inseparably united with the other sensible qualities, and not even in thought capable of being abstracted from them, it plainly follows that they exist only in the mind. But I desire any one to reflect, and try whether he can, by any abstraction of thought, conceive the extension and motion of a body without all other sensible qualities. For my own part, I see evidently that it is not in my power to frame an idea of a body extended and moved, but I must withal give it some colour, or other sensible quality, which is acknowledged to exist only in the mind. In short, extension, figure, and motion, abstracted from all qualities, are inconceivable. Where, therefore, the other sensible qualities are, there must be these also, to wit, in the mind, and no where else."

Before we advert to the way in which these arguments have been answered, we may take notice of the consequences which are supposed to flow from them. These are thought to amount to nothing less than the unhinging of all belief, and the introduction of universal scepticism. Nothing certainly could be farther from the intention of the amiable and ingenious author. For, in the preface to his Dialogues, he says, "If the principles which I here endeavour to propagate are admitted for true, the consequences I think that evidently flow from them are, that atheism and scepticism will be utterly destroyed; many intricate points made plain; great difficulties solved; speculation referred to practice; and men reduced from paradoxes to common sense."

In fact, nothing was ever so completely misunderstood and misrepresented as the system of Berkeley, and that too by men of some name in philosophy. Berkeley anticipated these conclusions, and, in our opinion, gives a most triumphant refutation of them. To do him full justice, we use his own words: "I am of a vulgar cast," says he, "simple enough to believe my senses, and leave things as I find them. It is my opinion, that the real things are those very things I see, and feel, and perceive by my senses. That a thing should really be perceived by my senses, and at the same time not really exist, is to me a plain contradiction. When I deny sensible things an existence out of the mind, I do not mean *my* mind in particular, but *all* minds. Now it is plain they have an existence exterior to my mind, since I find them, by experience, to be independent of it. There is, therefore, some other mind wherein they exist during the intervals between the times of my perceiving them, as likewise they did before my birth, and would do after my annihilation. And as the same is true with regard to all other finite created spirits, it necessarily follows that there is an omnipotent eternal mind, which knows and comprehends all things, and exhibits them to our view in such a manner, and according to such rules, as he himself hath ordained, and are by us termed the laws of nature."

* An attempt is made to explain Kant's system in the second number of the *Edinburgh Review*. See also Sir W. Drummond's *Academical Questions*, and De Gerando, *Hist. de Systemes*, tom. ii. p. 208, 209.

† See the article Kant, where a general view of his philosophy is given by a gentleman who has *read*, and probably understood his works. Ed.

No man who knows any thing of philosophy can doubt that all this is perfectly possible, and, if received in the way in which Berkeley has explained it, could have no unfavourable influence on the conduct, the happiness, and the hopes of men; and we may affirm, without hesitation, that it is grossly misrepresented, and indeed totally misunderstood by Beattie, when he says, "It is subversive of man's most important interests, as a moral, intelligent, and percipient being; and not only so, but also, if it were universally and seriously adopted, the dissolution of society, and the destruction of mankind, would necessarily ensue within the compass of a month." So thought not Plato, who conceived it possible that life might be a continued sleep, and all our thoughts and sensations only dreams. Beattie seems to have confounded the principles of Berkeley with those of Pyrrho, who also denied the existence of the material world, in the most unqualified sense; so that his friends, as it is reported, were obliged to accompany him wherever he went, that he might not be run over by carriages, or fall down precipices.

We even think that Mr. Stewart, the most candid of all philosophers, has scarcely given a fair view of Berkeley's system, when comparing it with that of the Vedanti school among the Hindoos. "The difficulties," says Sir William Jones, "attending the vulgar notion of material substances, induced many of the wisest among the ancients, and some of the most enlightened among the moderns, as well as the Hindoo philosophers, to believe that the whole creation was rather an energy than a work, by which the infinite mind, who is present at all times, and in all places, exhibits to his creatures a set of perceptions like a wonderful picture, or piece of music, always varied, but always uniform." And again, "The Vedantis, unable to form a distinct idea of brute matter independent of mind, or to conceive that the work of supreme goodness was left a moment to itself, imagine that the Deity is ever present to his work, and constantly supports a series of perceptions, which in one sense they call illusory, though they cannot but admit the reality of all created forms, as far as the happiness of creatures can be affected by them."

Mr. Stewart says, that this creed of the Hindoos has not the most distant affinity, in its origin or tendency, to the system of idealism, as it is now commonly understood in this part of the world; the former taking its rise from a high theological speculation; the latter being deduced as a sceptical consequence from a particular hypothesis concerning the origin of our knowledge, inculcated by the schoolmen, and adopted by Locke and his followers. Whatever difference there may be as to the origin of the ideal system and that of the Hindoos, there can be little doubt that Berkeley's principles led him to nearly the same conclusions. The passage already quoted seems clearly to prove this; for he says, "It necessarily follows, that there is an omnipotent eternal mind, which knows and comprehends all things, and exhibits them to our view in such a manner, and according to such rules, as he himself hath ordained, and are by us termed the laws of nature."

On this system of Berkeley was founded the contemptible scepticism of Hume. We could respect an honest sceptic who erred in his researches after truth. But Hume was not an honest sceptic: he had as little faith in his scepticism as in the creed of his country, and was actuated solely by vanity, in the attempt which he made to unhinge the belief of mankind. It has been beautifully observed by Mr. Stewart, that his aim was, not to *interrogate* nature with a view to the discovery of truth, but, by a *cross-examination* of nature, to involve her in such contradictions as might set aside the whole of her evidence as good for nothing." (*Phil. Essays.*) Berkeley having said, that matter and all its qualities have no existence but in the ideas which are in our own minds, Hume proceeded a step farther, and endeavoured to shew that nothing could exist but the impressions of our own minds; by which argument he wished to sweep away the world of spirits, and the Father of spirits. This is a pitiful sophism, which Berkeley foresaw and obviated. He introduces one of the interlocutors in his dialogues as drawing these very consequences from his principles: "In consequence of your own principles, it should follow, that you are only a system of floating ideas, without any substance to support them; and as there is no more meaning in spiritual substance than in material substance, the one is to be exploded as well as the other." To this the other speaker, who supports Berkeley's principles, answers: "How often must I repeat, that I know or am conscious of my own being, and that I myself am not my ideas, but something else; a thinking, active principle, that perceives, knows, wills, and operates about ideas? I know that I, and the same self, perceive both colours and sounds; and that a colour cannot perceive a sound, nor a sound a colour; that I am therefore one independent principle, distinct from colour and sound; and, for the same reason, from all other sensible things and inert ideas. Farther, I know what I mean when I affirm, that there is a spiritual substance, or support of ideas, that is, that a spirit knows and perceives ideas. But I do not know what is meant when it is said, that an unperceiving substance hath inherent in it, and supports either ideas, or the archetypes of ideas." And afterwards he says, "My own mind and my own ideas I have an immediate knowledge of; and, by the help of these, do immediately apprehend the *possibility* of the existence of other spirits and ideas. Farther, from my being, and from the dependency I feel in myself and my ideas, I do, by an act of reason, *necessarily* infer the existence of a God, and of all created things in the mind of God."

Dr. Reid (whom we have heard called the Newton of pneumatology) admits, that Berkeley's system was perfectly incontrovertible, according to the received doctrines respecting the origin of our ideas. He employs a distinction which Berkeley himself had introduced, and says, that although we cannot have an *idea* of matter, as an *idea* can exist only in the mind, yet we may have a *notion* of it; as Berkeley himself admits, that though he cannot have an idea of God, yet he can have a *notion* of his existence. But Reid says this only to combat Berkeley's pretended demonstration of the impossibility of the existence of material substances: he does not attempt to prove the actual existence of matter, but assumes it as an axiom which cannot be proved, because there is no truth plainer than itself. Now, though we do not pretend to say that Descartes was completely successful in his attempt to demonstrate the existence of a material world, yet we certainly do think him completely successful in demonstrating the *possibility* of its existence. He admits the possibility of Berkeley's system, though no one had then promulgated it to the world; for he says he conceived it possible, that his waking thoughts and sensations might be of the same nature with those which passed through the mind in sleep, which he knew could not proceed from external objects. His maxim being to doubt of every thing till it was proved by demonstration, his first ground of douht as to the existence of the external world is stated in these words: " *Quod nulla unquam dum vigilo me sentire crediderim, quæ non etiam inter dormiendum possim aliquando putare me sentire: cumque illa quæ sentire mihi videor in somnis, non credam a rebus extra me positis mihi advenire, non advertebam. quare id potius crederem de iis quæ sentire mihi videor vigilando. Meditatio sexta.*" This is certainly giving all due advantage to the system which he was to oppose. He then proceeds to state the arguments which induced him to believe that matter might exist. He says, that whatever we can clearly conceive is possible; that we are conscious of certain faculties of the mind, such as sensation, imagination, and the like; but that we cannot conceive these to exist except in an intelligent substance. In the same manner, we are forced to recognize certain powers, such as motion, change of shape, and the like, which we must also consider as belonging to some substance, otherwise they would be inconceivable. But it is evident these powers, of which he have such a clear conception, must belong to corporeal or extended substance; for they are inconceivable as applied to mind.

We are not sure that any thing more satisfactory has been written in answer to Berkeley, than these arguments of Descartes, which were written so long before he was born. In fact, they appear to us to give exactly the same evidence for the existence of matter, as we have for our own existence; and this is, on all hands, admitted not to need a proof. Grant the existence of mind, then, and we think Descartes has approached as near as possible to a demonstration of the existence of matter. We think it proper that he should speak for himself on this subject. " *Præterea invenio in me facultates specialibus quibusdam modis cogitandi præditas, puta facultates imaginandi et sentiendi, sine quibus totum me possum clare et distincte intelligere, sed non vice versa illas sine me, hoc est, sine substantia intelligente cui insint: intellectionem enim nonnullam in suo formali conceptu includunt, unde percipio illas a me, ut modos a re distingui. Agnosco etiam quasdam alias facultates, ut locum mutandi, varias figuras induendi, et similes, quæ quidem non magis quam præcedentes. absque aliqua substantia cui insint possunt intelligi; nec proinde etiam absque illa existere. Sed manifestum est has, si quidem existant, inesse debere substantiæ corporeæ sive extensæ non autem intelligenti; quia nempe aliqua extensio non autem ulla plane intellectio in earum claro et distincto conceptu continetur.*"

Or his argument may be put thus: If we can form an idea of extension, motion, form, &c. which undoubtedly we can, then they may exist; and as they cannot exist in a spiritual substance, they must be attributes of something else; and the only other substance of which we have any knowledge, is that which we call matter. We think this completely oversets Berkeley's argument as to the *impossibility* of material existence.

We admit. however, that it does not amount to a demonstration that matter actually exists, except on Descartes' principle, that every thing which can conceive must, somewhere or other, have an archetype. They who would wish to retain their belief in the existence of the material world, had better not bring it to the hazard of a proof, or we fear Berkeley will be too much for them. Dr. Reid, the most strenuous impugner of Berkeley's system, was once a decided Berkeleian. " I once believed this doctrine of ideas so firmly," says he, " as to adopt the whole of Berkeley's system in consequence of it; till finding some consequences to follow from it, which gave me more uneasiness than the want of a material world, it came into my mind, more than forty years ago, to put the question, what evidence have I for the doctrine, that all the objects of my knowledge are ideas in my own mind?" The truth is, if the existence of matter is not admitted as an intuitive perception, it will be impossible to prove it. Certainly nothing is more incomprehensible than the mode in which material objects communicate sensations to our minds. We rather think Berkeley's system more intelligible than the orthodox opinion; and we would gladly embrace it if we could. But it presents this formidable objection, that, if we are deceived as to the existence of matter, we may be deceived in every thing else; for nothing is more certain.

The fate of Descartes' celebrated axiom to prove his own existence, should teach us to beware of attempting to explain ultimate principles. *Cogito, ergo sum*, he considered as incontrovertible; but it involves a *petitio principii* in the very first step. *Cogito* is equivalent to, *I am a thinking being*, and *ergo sum*, to *therefore I am in being*. Here it is evident that every thing is assumed. The premises imply, that he exists as a thinking being; and then he employs them to prove that he exists at all. The syllogism to which his proposition may be reduced has been justly compared to that ridiculed by Cicero: *Si lucet, lucet: lucet autem: lucet igitur.*

Thus we have seen, that one consequence of Locke's philosophy has been, the denial of the existence of the material world by Berkeley and his followers. This consequence naturally enough arose out of the received doctrine concerning ideas, and particularly from Locke's assertion, that the ideas of the primary qualities of matter were actual resemblances; whilst he admitted, that the ideas of the secondary qualities were only sensations in our own minds. Berkeley easily perceived, that there could be no more resemblance between extension and the idea it produced in the mind, than between the sensation of smell and the object which excited it; and on this he built his system. D'Alembert, though a disciple of Locke, had much more correct views on this subject: he says, that the sensation, by means of which we arrive at the knowledge of *extension*, is, in its nature, as incomprehensible as extension itself. And, in the preliminary Discourse to the *Encyclopedie*, he says, that as there is no relation whatever between a sensation and the object which excites it, or to which we refer it, we cannot trace, by reasoning, any possible passage from the one to the other; and therefore he thinks, that it is by a species of instinct that we are forced across the gulf which separates mind from matter; a mode of reasoning very nearly coinciding with that of Dr. Reid.

We now turn to the consideration of some other inferences deduced by the continental philosophers from Locke's principles, which are the very reverse of Berkeley's ideal scheme. If it is true that sensation is the inlet of all our knowledge, it seems to follow, as a natural consequence, that there can be no ideas in the mind but such as have their orgin in material and sensible objects. At least this is the use which has been made of

Locke's doctrine by the materialists on the continent. We shall see by and by, that other continental writers give a very different interpretation to it.

The doctrine of the materialists, as deduced from Locke's principles, is thus stated by Diderot, in the 6th volume of his works. We use the words of Mr. Stewart with very little alteration, which combine the light of a commentary with the fidelity of a translation. "Every idea must necessarily, when brought to its state of ultimate decomposition, resolve itself into a *sensible* representation or picture; and since every thing *in* our understanding has been introduced there by the channel of sensation, whatever proceeds *out* of the understanding is either chimerical, or must be able, in returning by the same road, to re-attach itself to its sensible archetype. Hence an important rule in philosophy, that every expression which cannot find an external and a sensible object to which it can attach itself, is destitute of signification."

These are certainly most portentous consequences of Locke's doctrine, and such as neither he nor any of his sober admirers ever contemplated. They are made the foundation of the most avowed and unqualified *materialism;* and are employed to persuade us that we ought to reject from the book of human knowledge, every word which does not present a notion copied like a picture or image, from some archetype among the objects of external perception.

Such are the natural consequences of interpreting too literally the maxim of the schools, commonly supposed to have been prescribed by Aristotle, but which was framed in latter times, as a corollary deducible from his doctrine. The maxim, *Nihil est in intellectu, quod non fuit prius in sensu*, when literally understood, must necessarily, we should think, lead to materialism: for it implies that *the senses are the beginning and the end of all our knowledge;* a maxim which might easily be employed to cut up by the roots metaphysics, ethics, and religion. It is unfortunate that these sceptics, who have so eagerly perverted the doctrine, did not attend to a most judicious criticism made by Leibnitz, on the fundamental principle of Locke's system. It is in these words: *Nempe, nihil est in intellectu, quod non fuerit in sensu*, NISI IPSE INTELLECTUS. Had Hume attended to this, he never would have confounded mind with its impressions, nor supposed it possible for them to exist but in a spiritual and intelligent substance.

The error of Hume, as well as of the contintental materialists, who attempt to build their systems on Locke's principles, consists in this, that they view the mind merely as a kind of intellectual machine, or *æsthetical* instrument, which receives impressions something in the same way as a *camera obscura*, with this only difference, that the figures, once introduced, remain as it were in some quiet corner, till, on the introduction of some of their old friends, they start forth to renew their acquaintance. But in all these theories the attention is confined entirely to what may be called the mechanism of perception, whilst no regard whatever is paid to the *perceiving* principle. It would be just as rational to suppose that a clock not only *indicates* the hours, but *perceives* and *calculates* the flux of time, as to suppose that any sensation whatever could arise in a mere material substance; the very conception of which implies that it is insentient. To say that extension, figure, motion, solidity, &c. can ever by any possible combination become susceptible of thought and volition, is as inconceivable, and as utterly repugnant to every principle of sense and reason, as it would be to suppose that a thing may be *itself* and its contrary at the same time; or that a figure may be at one and the same time a square and a circle; or that light and darkness may exist in the same place, and at the same instant. In short, the sceptics confound themselves and their followers, by making the mind itself the *instrument* of sensation, instead of ascribing this office to the organs of sense, with which the body is furnished. So distinct is the mind from the materials furnished by the senses, that we firmly believe its most important feelings are independent of the senses: we mean the feelings of pleasure and pain, which are coeval with our existence as sentient beings, and may be, nay, we doubt not, must be perceived, before the senses are called into exercise. All that the senses do, so far as the mere animal is concerned, is to supply those pleasures which the mind desires, or to remove the uneasiness which it feels: and we have elsewhere supposed, and we think it incontrovertible, that the mind may continue susceptible of pleasure or of pain in the absence of all the external senses. Take away sight, hearing, taste, and smell, will a man then be incapable of feeling pleasure and pain? No. Take away the remaining sense of touch; is he then an insentient mass? No: supply his wants, and he will still be happy, so far as his mere animal existence is concerned.

We have seen some very sober philosophers leading themselves astray with the greatest deliberation on this subject; puzzling themselves to which of the senses they should ascribe pleasure and pain, and the like; evidently supposing all along, that the senses were themselves sentient, and not mere instruments of sensation. When a man sees with a telescope a star invisible to the naked eye, or hears with an ear-trumpet a sound otherwise inaudible, he would not surely say that the telescope sees, or that the trumpet hears: and it would be as improper, strictly speaking, to say that the eye sees or the ear hears: but it is accurate as well as philosophical language, to say that we see with the eye and hear with the ear. Had the sceptical writers attended to this, they never would have confounded the mind with its ideas, and the thinking principle with the instruments which it employs, and the perceptions of which it is conscious.

It is true, indeed, we know matter only by its qualities, and mind by its operations: still, however, we have an irresistible conviction that there is something more than the mere qualities of matter to serve as a *substratum*, in which they must inhere, otherwise matter could not exist; for the qualities of matter are not material, any more than the sensations of mind are sentient. In both there must be an invisible, incomprehensible *substratum;* in the one case, as the recipient of qualities, in the other, of sensations. And we have always been of opinion that, were the question to lie solely between the materialists and the idealists, every philosophical, as well as every pious mind must, without hesitation, give its suffrages in favour of the latter, and cling to them, as the best supporters of the dignity and immortal hopes of man. For we say again, that Berkeley's system is infinitely more intelligible than its opposite, we mean than that which would banish mind from the universe; for in that case matter would be inconceivable.

We must therefore be content to embrace the whole system, and admit the existence of mind and matter as ultimate facts, of which we can give no account, (otherwise they would not be ultimate,) and as therefore referable alone to the sovereign will of him who commanded all things to be as they are. It is sufficient that we know the existence of our own minds by consciousness, and the existence of the external world by perception. Of these two points we are absolutely certain, if there is any certainty in human knowledge; if there is not, it is equally in vain to argue on the one side or on the other. This seems to be the conclusion to which Hume would wish to reduce us; and it is the conclusion of one who ought to be denounced as the assassin of human happiness. To the authors of all such attempts, the words of Seneca are peculiarly applicable. "*Non facile dixerim, utrum magis irascor illis, qui nos nihil scire voluerunt, an illis, qui ne hoc quidem nobis reliquerunt, nihil scire.*"

But here we must observe, that though on the admission of a material world, and of the infallibility of the scholastic maxim, *Nihil fuit in intellectu quod non fuit prius in sensu*, the consequences which Diderot, and the other materialists, deduced from these premises must naturally follow, yet on the scheme of Berkeley the maxim of the schools is perfectly harmless; nay, it is the very foundation of his doctrine: and several of the continental philosophers have adopted Diderot's premises without coming to the same conclusion. In the Transactions of the Berlin Academy for the year 1757, there is a paper by M. Merian, in which he adopts, in their full extent, the very principles which Diderot makes the foundation of materialism, and argues that such consequences by no means follow from them. "If we are once fully persuaded," says he, "that sensation is the foundation of all our knowledge, we have only a single step to advance, to be convinced that all our knowledge consists of sensations. It is even impossible to conceive that our knowledge, being mere sensation in its origin, should ever become any thing but sensation, by any after process. Such a transition would not be a change, but a magical transformation; in consequence of which, sensation must have been annihilated, and a new set of ideas must have sprung out of nonentity."* Nothing can be more decisive than this: yet this author is not a materialist. He seems to adopt the opinion of Berkeley; without, however, mentioning his name, or alluding to his system. For, in a subsequent part of the same paper, he makes the following observations. "The materialists believe that the ground is all their own, when we admit that all the faculties of the soul may be reduced to the senses; and the *spiritualists* think their cause essentially injured by this concession. In this instance, both parties are under the influence of prejudice; for what is that *matter* of which the one is so fond, and the other so much afraid? *Is it any thing else than an assemblage of sensations?* The fundamental error of *materialism* lies in confounding the sentient substance with some of its particular sensations; and the state of the soul with the soul itself. It would be absurd to say that the soul is white, or black, or cold, or hot: and it is not less absurd to say, that it is extended or solid. These are all sensations which the soul feels, but they are not the soul itself: and every one of these sensations I may cease to feel, yet my soul will not, on that account, cease to exist.†

The great error of the French philosophers arose from their excessive love of generalization. Locke had simplified the philosophy of the human mind, by reducing all mental phenomena to sensation and reflection. Sensation is the grand inlet of knowledge; and out of the materials which have thus been introduced into the mind, various compounds are formed, the constituent parts of which have all entered by the senses. The doctrine very evidently points out a farther simplification; for since Locke's ideas of reflection are only modifications of the ideas received by sensation, it naturally enough follows that every idea of the human mind may ultimately be referred to sensation. On these principles Helvetius constructed his system, and referred all the phenomena of mind immediately to sensation, which he calls *sensibilité physique*.

He begins, very unphilosophically, we must be permitted to think, to prove that memory is only *sensation continued*, but weakened. We have elsewhere called memory a kind of *continuous perception*, by which we merely mean the retention of the original idea; but we assign to memory much more important purposes than this: it supplies the place of instinct; and when various objects are presented to the mind, if they have ever passed in review before it at any other time, the memory, by recollecting the qualities of each, enables the mind to form an immediate decision respecting them. But in all this there is no sensation: on the contrary, memory and sensation cannot exist together, on any principle of philosophical propriety: the memory, we believe, merely exhibits the signs of past sensations; and when these happen to excite an uncommonly lively interest, so that the original feelings are reproduced, we could not, in strictness of speech, call that *memory*; it is intense feeling; it is, in the strictest sense of the word, sensation.

To complete his plan, he has only to prove next, that *judgment* is a modification of sensation. And he makes this supposition: A question is agitated, the object of which is to decide, whether Justice or Generosity be the most useful qualities in the ruler of a state? And he attempts to prove, that this moral question is decided on the principle of sensation. For how, says he, would the orator, or the poet, represent this subject? The orator, he remarks, will present

* Si nous sommes une fois bien persuadés que les sensations sont le commencement des nos connoissances; il ne nous reste qu'un pas a faire nous persuader que toutes nos connoissances sont des sensations. Il est meme assez difficile à concevoir qu'avant d'abord é é des sensations, elles ayent pu devenir autre chose; ce ne seroit pas la un changement; ce seroit une transformation magique: il faudroit que la sensation eut peri, et que l'idée qui lui succede eût été tiree du neant; et il seroit faux que toutes nos connoissances prennent leur origin des sens.

† Les materialistes croyent avoir tout gagné quand on leur accorde que toutes les facultés de l'ame se reduisent aux sens; et les spiritualistes croiroient nuire essentiallement à leur cause en faisant cette concession. Prejugé le part et d'autre. On ne prouvera jamais qu'il soit plus facile à la matiere de sentir que raisonner: et puis qu'est ce que cette matiere dont les uns sont si amoureux, et que les autres ont si fort en aversion? Nous ne la connoissons que comme une assemblage des sensations. L'erreur du materialism c'est de confondre l'Etre sentant avec quelques unes de ses sensations particulieres, un etat de l'âme avec l'âme elle meme. Si je suis une sensation, laquelle voulez-vous que je sois? Si je suis un assemblage de sensations, quel assemblage? Il y a autant de raison de dire que je suis le blanc ou le noir, le chaud ou le froid, le dur ou le moû, ou tout cela ensemble, que de dire que je suis l'etendu ou le solide; tout cela c'est des sensations que j'eprouve: c'est ne donc pas moi-même; je ne puis cesser d'être moi; et il n'y a aucune de ces choses que je ne puisse cesser d'être.

to the imagination three pictures: in the one he will exhibit a just king condemning a criminal, and causing him to be executed: in another, he will represent a generous prince, opening the doors of the prison, and striking off the fetters from the criminal: and, in the third picture, he would shew the same criminal, immediately on his escape from the prison, arming himself with a dagger, and murdering fifty citizens. These representations would instantly enable any man to decide that justice was the most valuable quality in a ruler; and that it was real mercy to sacrifice one for the safety of many. Helvetius having thus analysed, as he thinks, the sentiment which ought to arise in the mind, by exhibiting the visible signs employed to represent it, he tells us, in conclusion, that all this is mere sensation.

There is, certainly, here, a gross abuse of language, and a great want of philosophical precision. For our part, were we even to see the assassin plunge the knife into the breast of his friend, we should scarcely think that the sentiment of horror which would arise in the mind could be ascribed to *sensibilité physique*. We would ascribe it to a moral sensibility; and are inclined to think that the physical sensibility of Helvetius is a phrase scarcely admissible in philosophy.

But both he, and many others of the French philosophers, have been misled by the material origin of the words, in which even the most refined, moral, and spiritual ideas of the mind are expressed. We have endeavoured to shew (see Logic) that every word of which language is composed, is originally a picture, drawn from material objects; and that as mind can only be known by certain sensible effects, its operations never can be explained but by sensible images. There is an obvious analogy between the progress and culture of the mind, and many of the objects of external nature; between the growth of our bodies, for instance, and the enlargement of our faculties; or between the progress of our minds, and that of vegetable nature; and therefore the one can be employed to illustrate the other without the smallest confusion, or the least danger of confounding their identity. We talk of *cultivating* the mind, or of *cultivating* a field, without the smallest danger of mistake; and we are as little apt to suppose the mind material from this mode of speaking, as we would be to mistake the respective culture of each; or to imagine that the manure employed to fertilize the fields could be applied to the improvement of the human mind.

We can admit, then, without the smallest fear for the consequences, that even the words which express spiritual ideas have a material origin: they are merely the description of certain visible effects, by which the soul manifests its operations; and, when we talk of a storm, or a conflict in the soul, we are merely borrowing what we conceive to be an analogous representation to make known the troubled state of our feelings.

We may here observe, that though Helvetius adopts the same doctrine with Diderot, as to the origin of our knowledge; yet he is not a professed materialist. He says his doctrine is equally reconcileable with both plans; and he very absurdly alleges, that the existence of the soul as a thinking substance distinct from matter, is a doctrine which could only be established by the authority of the church. This is a very suspicious way of talking; it was very generally adopted by Hume and all the sceptics who had not sufficient courage to avow their disbelief of Christianity, but who brought it forward on all occasions, as patronizing dubious opinions, and as establishing certain doctrines which they affect to spare because they are sheltered by its authority. Thus Hume, in the conclusion of his Essay on Miracles, after having attempted to demonstrate that a miracle was impossible, and therefore could not be believed on any principle of reason, affects to say that it was made quite easy by Revelation, and that there could be no difficulty in believing, when we were thus positively commanded to do so. Helvetius was not distinguished for orthodoxy; but what he says respecting the soul seems rather to be in opposition to Descartes's pretended demonstration of its existence, than to have arisen from any sceptical doubt on the subject. Though he perceived that the subject was, in its nature, not susceptible of demonstration, yet he foolishly imagined that it was necessary to have some authority for believing it, not perceiving that ultimate facts, which admit of no proof, can be strengthened by no authority, but must rest on the evidence of our consciousness or of our senses, according as they belong to mind or to matter. *De l'Esprit, Chap. Prem.*

But it was not merely among the continental philosophers that Locke's doctrines were perverted from their original purpose, and made subservient to a scheme of materialism. The opposite system, indeed, obtained much more eclat in this country, and the abettors of materialism have scarcely acquired a name. Hartley, by his physiological theory of vibrations, seemed to give some countenance to it, though he himself protests, and we believe with perfect sincerity, against any intention of deducing such a conclusion from his hypothesis. This we can easily believe, when we find Malebranche, whose general doctrine certainly approached much nearer to the sentiments of the spiritualists than to those of the materialists, holding exactly the same opinions with Hartley as to the immediate cause of sensation. *La seconde chose*, says he, *qui se trouve dans chacune des sensations, est l'ebranlement, des fibres de nos nerfs, que se communique jusqu'au cerveau.* There could not possibly be a clearer anticipation of the Hartleian hypothesis; and it must also be evident that this hypothesis is entirely unsupported by proof. Hartley says that it is a sufficient proof of the truth of hypothesis, that it accounts for all the phenomena of sensation and perception: for, when the key answers to the cipher, he says, we may be sure that we have found the true one. There is a fallacy in this illustration. When we meet with an unintelligible cipher, and at last discover the means of explaining it, we may be sure that we have found the right principle; it can have no meaning or signification on any other. In the same manner, when we find a piece of mechanism designed for motion, a watch, for instance, standing still, or moving irregularly from the want of some particular wheels, and when we discover at last the wheels which exactly answer the purpose, we are sure they are the right ones.

But these illustrations are totally inapplicable, either to the phenomena of mind or to the laws of nature; for here the machine is not standing still, it is in constant and regular motion: and the question is, not to discover the wheel which is wanting, but the one which principally regulates the movements. Here any wheel in the series may be taken, according to the views and knowledge of individuals; and it will account for the motions of all which depend upon it. But if we inquire what put our first material wheel in motion, we shall find that it either depends on another, or that it derives its motion from a spring, or a weight, or from water, or wind, or steam, &c. Any of these will answer the purpose. In the same manner, the physical phenomena of the universe are equally explicable on the principle of Malebranche, who held that every effect was produced by the immediate interposition of Deity; or of Leibnitz, who maintained that there was a pre-established harmony between cause and effect, in consequence of which they acted together, without influencing each other; or of Spinoza, and the Materialists, who hold that matter is eternal, and possesses in itself the principles of motion; or of Berkeley, who contends that there is no matter, but all that we perceive is a vision of the mind. Each of these philosophers had a *key* which he thought was the right one. Hartley's cipher has neither use nor meaning without the *key*. The phenomena of mind, and of the visible universe, are equally interesting, although the real key should never be discovered.

Hartley's system has been adopted by Priestley and Darwin, who have founded on it a system of materialism. Their views, in establishing this conclusion, were, no doubt, very different. Darwin was regardless of consequences, in following out a philosophical theory, and was not withheld by any religious scruples from dismissing mind from the universe; whilst Priestley was led to imagine that it would materially strengthen his peculiar views of Christianity to suppose the soul material, and naturally perishable along with the body. In the Unitarian sheme which Priestley so warmly espoused, the death of Christ seems to present an insurmountable obstacle; and orthodox Christians ask why it should have taken place, attended by so many circumstances of pain and ignominy, if no object of great importance was to be accomplished by it? Priestley's answer is, that this event took place, that by our Saviour's resurrection the hopes of our naturally perishable souls might be revived, and we might thus be authorized to aspire after immortality. To give currency to this conceit, this precipitate and dogmatic reasoner chose to give up all the natural arguments for the soul's immortality, and to represent it as a material substance, and by necessary consequence, as he imagined, perishable in its nature. By this conduct he threw away many solid advantages, without gaining the shadow of a benefit in return; and his conclusion does not seem necessarily to follow from his own premises. For, even allowing the soul to be material, why should it, on that account, be mortal? If the Almighty could endow matter with the power of feeling, thinking, &c. which Mr. Locke seems to think does not imply an absolute absurdity,* and which Dr. Priestley reasons upon as a thing ascertained, we do not see why we should conclude such a substance to be naturally mortal and perishing. In fact, we believe matter to be as imperishable in its nature as mind itself. We see no process which can give us any idea of the annihilation of matter. We see alteration, decomposition, division, dissolution, and all this without the loss of a single integrant particle of the original mass. We do not, however, mean to say, that either mind or matter are naturally and independently immortal; but this we say, that nothing but the same power which called them into existence can reduce them to annihilation. Yet we hold it absurd to talk of any created substance as naturally and essentially immortal; for, if we might presume to assign any bounds to the power of the Almighty, we would say it was limited by this, that he could not make any created substance independent of himself.

We have perhaps said more than enough of Priestley, who is unworthy of notice as a metaphysician; and whose character as a philosopher must rest on his physical researches. He had an acute mind; but he fell into the error which has misled many incipient metaphysicians; for he thought that he needed only to draw from his own resources; and that, the province of mind being always accessible, he might find in his own stores those materials of knowledge which others seek by painful study in the works of the learned. Such a temper has its advantages; but they are nearly counterbalanced by opposite inconveniences. For whilst, on the one hand, the fearlessness of discussion which distinguished Priestley may occasionally strike out new lights, and lead into a path of investigation hitherto unattempted; there is, on the other hand, a danger that the mind which is unacquainted with what others have already done, may be wasting its strength in pursuing phantoms which have already been hunted down, or in toiling to erect a fabric which has already been constructed. Every metaphysician should be acquainted with the labours of his predecessors: and with their knowledge, combined with his own independence of thinking, he may hope to extend the boundaries of science, and to earn well-deserved laurels, in the ample field presented to him by the *first philosophy*.

Of all the French philosophers, Condillac has obtained the highest applause as a commentator on Locke; and indeed it seems to be chiefly through him that Locke's writings are known in France; at least all the philosophers of that country have, without exception, adopted his interpretation of Locke' doctrine; though they are very far from being agreed as to the consequences which may be deduced from it. "Give me matter and motion," said Descartes, "and I will make a world."—"Give me sensation," Condillac seems to say, "and I will make a man." In his Essay on the origin of Human Knowledge, there is often much ingenuity, but there is fully as much of confident assertion. He lays great stress on attention, and makes it a principal instrument of transforming his ideas of sensation into those which we are accustomed to call ideas of reflection. He seems to have given the cue to Mr. Stewart, and some other succeeding philosophers, to consider *attention* as an original power of the mind; though we think it is neither more nor less than a natural or artificial in-

* "We have the ideas of *matter* and *thinking*, but possibly shall never be able to know, whether any mere material being thinks or no; it being impossible for us, by the contemplation of our own ideas, without revelation, to discover whether omnipotency has not given to some systems of matter fitly disposed, a power to perceive and think, or else joined, and fixed to matter so disposed, a thinking immaterial substance, it being, in respect to our notions, not much more remote from our comprehension to conceive, that God can, if he pleases, superadd to matter a faculty of thinking, than that he should superadd to it another substance, with a faculty of thinking." Book IV. Ch. 3. § 6. 6. We think some of the ideas advanced in this passage unworthy of Locke. According to this way of reasoning, we can never say that we can be sure of any thing, because we do not know the extent of Almighty power. We are surely warranted to say, that nothing can exist which implies a contradiction, that a thing cannot be itself, and another thing at the same time; and we can just as easily conceive, that a thing should be black and white, or hot and cold, or fluid and solid, at the same instant, as that mind should be matter, or that matter should think.

terest lent to the affections. Condillac has also made great use of the principle of association, as the means of effecting a transmutation of sensations into ideas the most recondite and profound. This was also the grand *arcanum* of Hartley's system, which was published after Condillac's *Essai sur l'Origine des Connoissances Humaines*; yet we do not mean to say that it was borrowed from it. It seems to form an unavoidable article in every system which assumes sensation alone as the origin of human knowledge, and therefore may be claimed as common property by all who hold this creed.

This coincidence between the opinions of Condillac and Hartley has been observed by Mr. Stewart; but there is a still more striking resemblance between their physiological theories, which he has not noticed. "I suppose here, and in other places," says Condillac, "that the physical cause of the perceptions of the mind, is the concussion of the fibres of the brain; not that I look upon this hypothesis as demonstrated; but that it seems the best adapted for explaining my thought. If this is not the way they are produced, it must be in some other, not very different manner. *For the brain can be acted upon only by motion.* Therefore, whether we suppose the perceptions are occasioned by the concussion of the fibres, or by the circulation of the animal spirits, or by some other cause, it is all the same to the purpose of this discourse." Nugent's Translation.

But the truth is, that the more we extend our knowledge of the history of philosophy, we will be the more struck with the similarity of opinions, and the apparent want of originality among the different authors. In most cases, these coincidences are the effect of ignorance as much as of imitation: for, not knowing what has been done before them, many writers continue to tread in the track of their predecessors, and think, all the while, that they are enlightening the world with original discoveries.

Mr. Stewart leans towards the opinion of Cudworth, and others, who maintain that certain ideas, which never could enter the mind by sensation, are generated by a process of reasoning, or spring out of the natural resources of the understanding. Cudworth compares the visible universe to a well written book, which conveys both pleasure and information to a cultivated mind, but is totally unintelligible to an ignorant person or a brute. "To the eyes of both the same characters will appear; but the learned man, in those characters, will see, heaven, earth, sun, and stars; read profound theorems of philosophy or geometry; learn a great deal of new knowledge from them; and admire the wisdom of the composer; while to the other, nothing appears but black strokes, drawn on white paper. The reason of which is, that the mind of the one is furnished with certain previous inward anticipations, ideas, and instruction, that the other wants."—"In the room of this book of human composition, let us now substitute the book of nature, written all over with the characters and impressions of divine wisdom and goodness, but legible only to the intellectual eye. To the sense both of man and brute, there appears nothing else in it, but, as in the other, so many inky scrawls; that is, nothing but colours and figures. But the mind which hath a participation of the divine wisdom that made it, upon occasion of these sensible delineations, exerting its own inward activity, will have not only a wonderful scene, and large prospects of other thoughts laid open before it, and variety of knowledge, logical, mathematical, and moral, displayed; but also clearly read the divine wisdom and goodness in every page of this great volume, as it were, written in large and legible characters." This passage contains nearly a summary of Mr. Stewart's doctrine, which he thus briefly explains in his Philosophical Essays. "All our simple notions, or, in other words, all the primary elements of our knowledge, are either presented to the mind immediately by the powers of consciousness and of perception, or they are gradually unfolded in the exercise of the various faculties which characterize the human understanding. According to this view of the subject, *the sum total of our knowledge may undoubtedly be said to originate in sensation*, inasmuch as it is by impressions from without, that consciousness is first awakened, and the different faculties of the understanding put in action." At the same time, he admits that this enunciation is liable to the grossest misconstruction, as is exemplified in the crude notions of Locke's French commentators.

That many important truths, which cannot be traced to sensation, in the sense in which Locke understood the word, gain admission into the human mind, is perfectly apparent, when we consider that mathematical truths are eternal, and necessary, and are forced on the mind by an intuitive conviction, and not in consequence of the experience which we have had of their certainty. This was early perceived by Leibnitz, who says, that if Locke had been careful to distinguish between necessary or demonstrative truths, and those with which we become acquainted by experience and induction, he would have perceived that the former could only be proved by a power of intuition inherent in the human mind; and not by a reference to any knowledge already acquired by the senses. This is a commentary rather than a translation; but we think it sufficiently expresses the sense of the author. *Si Lockius discrimen inter veritates necessarias seu demonstratione perceptas, et eas quæ nobis sola inductione innotescunt, satis considerasset; animadvertisset necessarias non posse combrobari, nisi ex principiis menti insitis; cum sensus quidem doceant quid fiat, sed non quid necessario fiat.*

For our part, though we certainly do not think that mathematical truths can be referred to sensation in the sense in which Locke understands the word; for they derive no confirmation from experience, being as convincing the first time they are presented to the mind, as after a hundred repetitions; yet we think they may find easy access to the mind by perception, in the extended view which we are disposed to take of it. For we maintain, that perception not only makes us acquainted with the existence of external objects, but with those circumstances, which, in process of time, come to constitute mathematical science. By perception, we not only discover the primary qualities of matter, such as extension, figure, &c. but we discover proportion, equality, resemblance, number, relation, analogy, and the like. When equal objects are presented, we see that they agree; when unequal, we see that they differ: and out of a few incontrovertible axioms, which the mind admits the moment they are presented to it, we erect that fabric of mathematical knowledge which is supposed by many to constitute the chief glory of the human understanding. Dr. Reid, on several occasions, seems willing to extend the boundaries of perception, and to allow it all the influence which we contend for; and we have only to regret, that he does not prosecute his views to their legitimate consequences. Towards the conclusion of his *Inquiry into the Human Mind*, he says, "Every operation of the senses, in its very nature, implies judgment, or belief, as well as simple apprehension. Thus, when I feel the pain of the gout in my toe, I have not only a notion of pain, but a belief of its existence, and a belief of some disorder in my toe which occasions it; and this belief is not produced by comparing ideas, and perceiving their agreements and disagreements; it is included in the very nature of the sensation. When I perceive a tree before me, my faculty of seeing gives me not only a notion, or simple apprehension of the tree, but a belief of its existence, and of its figure, distance, and magnitude; and this judgment, or belief, is not got by comparing ideas, it is included in the very nature of the perception."

In the rapid sketch which we have attempted to give of the progress of metaphysical science in modern times, our attention was necessarily led to Descartes as the founder of the modern school of metaphysics. Those who came after him, and who have taken the lead in such discussions, have done little more than modify or alter some subordinate points; whilst the grand pillar of the system, the doctrine of ideas, remained untouched: and Dr. Reid has very justly observed, that the system which, till his time, was generally received, with regard to the mind and it operations, derives not only its spirit from Descartes, but its fundamental principles; and after all, the improvements made by Malebranche, Locke, Berkeley, and Hume, may still be called the Cartesian system. The first of these philosophers must always be mentioned with respect as an original and profound thinker, and as a valuable contributor to the philosophy of mind; though we have not brought him forward in chronological order, having been carried along with the current of dominant opinion, which has thrown his writings aside, and consigned to neglect many elegant and valuable speculations. Indeed, he is so independent that he could scarcely be brought into the train of any other author: and he is so singular that he has had few followers, and has failed to establish himself as the head of a sect. The leading feature in his doctrine is, that the causes which philosophy investigates are only *occasional causes*, and that God himself is the efficient and immediate cause of every effect cognisable by our senses or our reason. It had been stated before his time, that we are completely ignorant of the manner in which physical causes and effects are connected; and that we saw nothing but a constant conjunction, and invariable sequence. This is a doctrine which afterwards brought considerable celebrity to the name of Hume, who is still by many supposed to have been the first who illustrated and explained it. But it was, in fact, unfolded at great length, and with great ingenuity, by Malebranche, whose doctrine of *occasional causes* hinges upon it. He supposed that what we call second causes have no existence, and that the divine power, incessantly and universally exerted, is the immediate cause of all the phenomena of nature. In this conclusion he went farther than his premises warranted: for though we cannot discover any necessary connection between physical causes, and the effects which follow, we are not therefore authorized to conclude that such connections are impossible. At all events, we may safely affirm, that the French metaphysician who introduced the immediate agency of the Deity in every visible change that takes place in the universe, is more fully warranted in his conclusion, than the English sceptic, who, from not perceiving any necessary link between preceding and subsequent phenomena, would have wished to persuade his readers, that they had no ground to infer, from any thing which they saw, the existence of an all-powerful and intelligent first cause. In fact, Dr. Clarke seems to have entertained nearly the same ideas as Malebranche respecting the laws of nature. "The course of nature," says he, "truly and properly speaking, is nothing but the will of God producing certain effects in a continued, regular, constant, and uniform manner."

Malebranche built a theory of perception on the same foundation: for as, according to his system, the agency of the Deity was interposed in carrying into effect every volition of the mind which prompted to bodily action, it was no less natural to conclude, that every *perception* was the effect of an immediate divine illumination. Hence he concluded, that the *ideas* of things exist only in the divine mind, and that *we see all things in God;* a notion which has often been ridiculed, and scarcely ever adopted by any succeeding author; but which bears a strong resemblance to some of the opinions of the latter Platonists, and more particularly to the system of some Hindoo philosophers, which we have already stated in the words of Sir William Jones. According to this system, the universe is to be considered rather as an energy than as a work by which the infinite mind, being everywhere always, exhibits to the minds of sentient beings a set of perceptions like a wonderful picture.

The *occasional causes* of Malebranche were attacked by Leibnitz, to make way for his doctrine of *pre-established harmony* and *sufficient reason.* It was objected that, according to Malebranche, every phenomenon in the universe was a miracle; an objection which is obviated by the regular course of nature; the disturbance or interruption of which constitutes a miracle. We are surprised to find a modern author*, of great metaphysical acumen, joining in the cry against Malebranche, and opposing his doctrine by such arguments as these: "Occasional causes are consistent neither with the omniscience, nor with the omnipotence of God. The acts of the Deity must be supposed as perfect as possible. It is not to be imagined that infinite power is continually employed in sustaining and repairing the tottering fabric of a crumbling edifice—the crazy constitution of the material world. It would, indeed, be to detract from the Divine Majesty, if we admitted this doctrine, and believed that a *curiosus et plenus negotii Deus* was perpetually busied in correcting the errors of his original plan, and in preventing the destruction of his own works." If no better arguments than these can be produced against the system of Malebranche, it may be pronounced to be unanswerable: for they are all drawn from the worst source of reasoning that can be conceived, viz. that of measuring the omnipotence of God by the limited powers of man. The objectors to Malebranche's system represent the universe as a machine contrived and set in motion by the wisdom and power of God, and rendered capable of continuing its operations in consequence of the constitution which it has received from omnipotence. This is to us inconceivable: we do not pretend to comprehend the operations of the Almighty;

* Sir William Drummond.

but we believe his presence constantly necessary for the preservation of every created thing; and that he could not make any thing capable of existing independent of his immediate power: for this would be to communicate his eternity and self-existence; which implies a contradiction: and the principle of *contradiction*, according to Wolff, the disciple and expounder of Leibnitz, is the test of truth.

We can conceive an engine, contrived by human skill, and put in motion by mechanical means, to be perfectly independent of the inventor. A mill, for instance, will continue in motion for ever, unless the materials give way, or the supply of water fail. The principle applied by the mill-wright may be said to be of perpetual operation; and when once employed has no farther dependence on him. But this reasoning is totally inapplicable to the eternal workman, who formed the stars of the heaven, and laid the foundations of the earth. The existence of the materials which compose the universe, and of the laws by which they are mutually affected, depend continually upon the will of him by whom they were created and ordained. He is the only principle of life and motion in the universe; and wherever the laws which he has appointed are in operation, we perceive his agency.

Perhaps Malebranche was precipitate in some of his conclusions; perhaps some invisible agent may be interposed to link together the phenomena of nature. But even admitting the possibility of this, it is only discovering another link in the chain of being which hangs from the throne of the Eternal. In fact, the system of Leibnitz does not appear to be essentially different from that which he opposes; and where it does differ from it, it seems to be worse, and savours more strongly of fatalism than the other does of enthusiasm. We pass over his system of monads, which he has borrowed or stolen from Pythagoras and other ancient philosophers, to consider that part of his doctrine which was intended to meet the arguments of Malebranche. It may be thus abridged: "As we are always able to assign the causes of every event with which we are perfectly acquainted, so we may assume it as true, that every thing exists for a *sufficient reason*; and that if we knew all the facts, we could always tell why every thing happens as it does, rather than otherwise. There being, then, a sufficient reason for every thing, and for the universe itself, that sufficient reason must be found in something. It cannot be found in the course of contingent events, because a contingency does not imply a necessary cause; and where the cause is not necessary, the reason cannot be sufficient, why a thing happens as it does, rather than otherwise. It cannot be discovered in what are called the qualities and substance of matter; because matter is inert, and because every change in its state being induced by a prior change, the series would be infinite, and the ultimate cause could not be found. The sufficient reason, then, which has occasioned the existence of every thing, can only be attributed to some intellectual substance, bearing in itself the reason of its own being, together with the knowledge why all things happen as they do, and not otherwise. This substance accounts to itself alone for all things, since it alone is acquainted with all things. It acts from itself, and for itself; and it ordains the being of atoms, and of worlds, of monads, and of systems, according to laws pre-established by infinite wisdom. This substance is God.

All things, therefore, act with each other, according to that *harmony* which has been *pre-established* by God, and which consequently is universal and necessary. By him our bodies are predisposed to obey the volitions of our souls. By him the individual monad, and the universe itself, were regulated in every vicissitude which they can experience. The soul acts not upon the body, nor does the body influence the soul. Their mutual concurrence was ordained by God himself, who, in regulating the order of worlds, regulated also all that they contain."*

This is certainly a bold attempt to account for the phenomena of the universe; but we cannot perceive a single advantage which it possesses over the system of Malebranche, to which it was opposed. It approaches nearer to fatalism; for, according to the doctrine of *pre-established harmony*, the Deity is supposed to have ordained all motion, and all change which may take place in corporeal substances. The human body acts in conjunction with the volitions of the soul, because it was predisposed to do so from eternity; and our limbs are moved, and our organs of sense are affected, by the immutable decrees of God himself.

This doctrine avoids the interpositions of Deity supposed by Malebranche; it also avoids the notion entertained by the author of the *Système de la Nature*, and other materialists, who maintain, that there is an efficient principle in every cause, which leads of itself, and by its independent influence, to the production of the effect. But it is clogged with difficulties equally perplexing, and consequences equally revolting. We cannot well see how any one can adopt it without admitting, that the Deity is the ultimate cause, if not the immediate instrument, of evil. It might lead to infer, that the Almighty could not be displeased with any action which men may commit, since every action and every volition are pre-ordained and pre-established to accompany each other; and we might suppose, that he organized for the very purpose the hand which should pollute his altars, and the tongue which would blaspheme his name. These consequences certainly were not intended to be deduced from this system by its very profound author; though they may be shewn to result from that harmony which he thought was pre-established for a sufficient reason.

But certainly one leading principle of the Leibnitzian system is not less applicable to that of Malebranche, who would readily have subscribed to the following maxim of the opposite school. "Ce n'est pas dans les corps qu'on peut decouvrir la raison pourquoi ils suivent ces loix plutot que tout autres; elle ne se trouve que dans une etre distinct des corps."

Before we leave Leibnitz and his school, which has never had much influence in this country, we may remark, that they are careful to distinguish between the *reason* why a thing is as it is, and the *cause* of its being as it is. This is particularly developed by Wolff, but it had been noticed by Descartes long before: "There is nothing which exists," says that philosopher, "respecting which we may not inquire into the *cause* of its existence. Such inquiries may be extended to God

* Academical Questions, p. 326.

himself; not that he needs any *cause* of his existence, but because the very immensity of his nature is the *reason* why he cannot have a *cause* of his existence. Sir William Drummond has, with much learning, traced the monads of Leibnitz up to their Pythagorean source, through all their windings, as discoverable in the writings of Hipprocrates, Stobæus, Sextus Empiricus, &c. and has shewn how largely the German philosopher has availed himself of the scattered fragments of Grecian ontology, which occur in the rarer and less accessible authors; we must therefore transfer to his learning whatever deductions we may be disposed to make from his originality. But his doctrine of sufficient reason is also borrowed; and its original may be found in the forty-sixth chapter of Plato's Phædon. Socrates is introduced as saying that he was delighted, when he found that Anaxagoras had assumed mind or intelligence as the origin of all things. He conceived, that this principle would be sufficient to account for any thing being as it is; because, if mind orders all things, they must be disposed in the situation and order which is best; and that if we wish to know why any thing is produced, or is destroyed, or exists as it is, we have only to inquire in what respects these several accidents and circumstances are most befitting in the cases in question. If any thing, for instance, happens to man, he is to consider that this, being regulated by supreme intelligence, must be the best that could befal him, and he has only to inquire in what respects it is best for him. In the same manner, after inquiring whether the earth be flat or round, the next point is to shew, in what respects that figure is best adapted to it. Were these things once properly settled, Socrates conceived that he would then have discovered a *sufficient reason* for the existence of things as they are, and that it would be unnecessary to search any farther into their causes.* We may easily perceive, then, that the doctrine for which this prince of philosophers expressed a partiality agrees, in many respects, with the *sufficient reason* of Leibnitz, and also with the doctrine which Pope undertook to illustrate without understanding it, that "whatever is, is right."

On a general view of the subject, we may distinguish three grand æras in the history of metaphysics, very unequal in point of time, but each of them marked with a very distinct and decided character. The first extends from the time of Aristotle to that of Descartes. During the currency of this long period, many persons arose, distinguished for metaphysical acumen, who attacked successfully some of the outworks of the Aristotelian doctrine; but they made little or no impression on the general scheme, and Aristotle continued the undisputed sovereign of metaphysicians. Lord Bacon gave a deadly blow to his empire, and was the first who shewed, in detail, the inutility of his method for the discovery of truth. Whether Descartes caught the spirit of Bacon, (if he did, he does not acknowledge it; for we do not recollect that any allusion is made to Bacon in any part of his works,) or whether the strength of his genius led him to assert the same independence of thinking, we know not; yet certain it is, that he introduced the same unfettered discussion into metaphysics, which Bacon had applied so successfully to the interpretation of nature. His method was both clear and original; and, in spite of the attempts which were made to resist it, it soon obtained possession of the schools, and drove Aristotle from the throne which he had occupied for so many hundred years. All the succeeding philosophers of any name were Cartesians; and Locke himself belonged to the same school, as has already been observed. But he served his master in the same way that he had done Aristotle, by pushing him from the seat of philosophy; and so complete was his victory, or his usurpation, that the name of his illustrious predecessor is now seldom mentioned as an authority in metaphysical science. But we certainly think it but justice to Descartes to say, that no man ever borrowed less from his predecessors. His whole efforts were directed to emancipate his mind from every prejudice, and to come unbiassed to the investigation of truth. There were some absurdities, however, connected with his doctrines, such as his *vortices* and innate ideas, by which he understood those ideas which he perceived could not enter by the external senses, and which he therefore supposed to exist in the mind previous to their exercise; these notions, as well as many other unauthorized assumptions, which were industriously exposed by his opponents, brought discredit on his doctrine, and prepared the world for the cautious and sensible system of Locke; who, rejecting what was false, or unwarranted, and retaining, explaining, and amplifying what was useful, justly merited the name of the founder of a new school in philosophy.

It was for a long time supposed that he had pre-occupied the ground as a metaphysician and pneumatologist, as completely as Newton had done in mathematics and natural philosophy. Indeed our brethren in the South seem, in general, to be still of the same opinion; and such of them as have extended their views a little farther, have not ventured to go beyond the speculations of Hartley. In short, England has been most exceedingly barren in metaphysicians, especially in later times; and had it not given birth to Cudworth, and Locke, and one or two more, it would scarcely have been known throughout Europe to have ever harboured the philosophy of the human mind. The northern part of our island has been much more productive in this species of literature; and the *Scotch school* has obtained a name on the Continent. Scotland has reason to be proud of this distinction; and its inhabitants are likely for a while, at least, to enjoy their laurels undisturbed, unless they are annoyed by the affected sneers of their neighbours at Scotch metaphysics, which, since the days of Hume, have been represented as synonymous with scepticism.

Reid deservedly takes the lead, as having brought about an important reformation in philosophy. He has

* Ακουσας μεν ποτε εκ βιβλιου τινος Αναξαγορου αναγιγνωσκοντος, και λεγοντος ως αρα νους εστι ὁ διακοσμων τε και παντων αιτιος, ταυτη δη τη αιτια ησθην τε, και εδοξε μοι τροπον τινα ευ εχειν, το τον νουν ειναι παντων αιτιον· και ἡγησαμην, ει τουτο ὁυτως εχει, τον γε νουν κοσμουντα, παντα κοσμειν, και εκαστον, τιθεναι ταυτη, οπη αν βελτιστα εχη. κ. τ. λ. Socrates, however, expresses his extreme regret at the disappointment of the high expectations which he had formed, when he first heard of Anaxagoras having introduced mind as the principle and disposer of all things. For he says that he did not find him treating of one of the subjects on which he wished to be informed, but bringing in aërial, etherial, or watery fluids to account for the constitution of things; and as the causes of the various phenomena which they exhibit.

not only corrected many mistakes of Locke; but he has endeavoured to explode the whole doctrine of ideas, which prevailed from the time of Aristotle till it was attacked by the Scotch philosopher. According to this doctrine, nothing can be present to the mind but an idea, which is supposed to be some kind of representation of the object from which it proceeds. It is not enough that the senses be affected in a particular way; the only result of such affection is the production of an idea, and this idea alone is perceived by the mind. Our readers must recollect, that when the Cartesians speak of *ideas*, they use the word in a sense quite different from its ordinary acceptation in our language. They understood an *idea* as a representation transmitted to the mind through the senses, and which communicates an impression without imparting any portion of its substance. This is the philosophical meaning of the word *idea*, as employed by Locke and all the Cartesians. In our language, it is now considered as synonymous with *notion* or *conception*.

The doctrine of *ideas* which had kept possession of the schools for upwards of two thousand years; (for it did not originate with Descartes, he only explained and illustrated it more fully than had ever been done before:) this doctrine originated in an attempt to solve the difficulty which has always been felt in understanding how material objects can make an impression on a spiritual substance like the soul; and, instead of being founded either on observation or induction, it rests on the flimsy basis of unwarranted analogies. It was thus illustrated by Aristotle and his followers: As wax receives the impression of a seal without the substance of the seal, or as a looking-glass receives the images of objects which are at a distance from it; in the same manner, the mind receives the representation of things which cannot penetrate it, or which may be at a distance from it. Such is the only foundation of the doctrine of ideas; and never, certainly, in the history of the world, did such momentous consequences arise out of a mere analogy. For many ages it filled the world with systems of philosophy; till at last it banished from the world every thing but ideas and impressions.

We admit that, in many instances, analogy is a legitimate ground of argument. When we meet with positive facts, which at first seem insolated, and not reducible to any general rule, we anxiously look around us for illustrations, under the firm conviction that the whole system of nature is linked together by indissoluble connections; and that nothing can appear separate and detached, except from our ignorance of its affinities and relations. When at last we discover a number of similar appearances, and perceive that become general which, at first, we reckoned singular and anomalous, we conceive that we have received a sufficient explanation, and have discovered a law of nature hitherto unknown. This, indeed, is the foundation of all sciences, except such as rest on axioms or necessary truths.

Had any one, then, been sensible of an image depicted on his mind, in the same manner as it is presented in a looking-glass, he might have fairly concluded that he had advanced a step in explaining the phenomena of perception. But we are conscious of nothing but sensations, which, in general, we can refer to certain organs; but beyond that every thing is inscrutable; and we may say of sensation what St. Augustine said of time, *Si non roges, intelligo.*

There is another circumstance which has misled philosophers on this subject. In vision, for instance, an actual picture is painted on the *retina*, and when this picture is not produced, there is no perception of visible objects. This lends some countenance to the opinion, that an actual picture must be presented to the mind in every act of perception. This is the most favourable example that can be produced in support of the doctrine of ideas; and yet we do not see that it advances our knowledge a single step as to the real nature of perception. We have got an additional preliminary fact; but we can scarcely be said to be nearer to ultimate knowledge; and the optician or phisiologist who is most intimately acquainted with the structore of the eye, knows no more of the nature of perception, than the clown who never heard of its lens, or coats, or humours.

They who have attempted to combine physiology with metaphysics, have endeavoured to penetrate a little farther behind the scenes, and have carried the image from the *retina* to the brain by means of the optic nerve. They have, no doubt, some grounds for this process; for when the optic nerve is destroyed, no sensation is produced. But it is quite clear that the image on the *retina* cannot be transmitted through the nerve on any principle of optics or mechanical philosophy. The picture on the *retina* is exactly the same as that which is produced by means of any lens similarly constructed: and even supposing it carried, by any process, to the brain, we still know no more of perception than we did before. For why should the mind be able to perceive this image, rather than the object itself from which it proceeds?

But, then, it is argued, that as we know for certain, that external objects cannot be present to the mind; (because the mind itself perceives that they are at a distance;) there must be some representations, or images of them, present to the mind, since a thing cannot act where it is not. Here again the principles of mechanical philosophy are brought in to explain a subject to which they are entirely inapplicable. It is said, indeed, that our senses are adapted for the communication of certain sensations. Taste, smell, sounds, are confined to particular organs; and without these organs, we can have no conception that such sensations could be excited: yet these sensations, as well as every other, are mere affections of our minds, bearing no conceivable resemblance to the qualities in external nature which produce them. Taste, and smell, and sound, are no more like any thing we perceive in the qualities of matter, than the written characters in music are like the melodious tunes which they represent.

We hold, then, that the affections of the senses are mere signs, or signals to the mind, to excite certain susceptibilities, or to call into exercise certain faculties. This perhaps might be admitted by all parties, upon allowing them to fix their own interpretation upon it. The Peripatetics and Cartesians would say, that the signs call the mind to the consideration of the subject, in the same manner as the picture of an acquaintance brings him to our recollection: whilst others would say, that they are *arbitrary* but *invariable* signs established by the author of our nature; bearing no kind of resemblance to the things which they represent, yet exhibiting them to the mind as infallibly, as the arbitrary characters of a known language convey to our minds an idea of the sentiments which they represent. The only difference between the two cases is this: that in the one, the signs are fixed by God, and are immutable; whilst in the other, they are selected by ourselves, and may be altered or varied at pleasure.

We venture, then, to call the intimations of our senses *natural characters*, which the author of our being has established as the *indices* of certain sensations: and there is, perhaps, about the same connection between the signs and the things signified, as there is between a smile and the feeling of happiness. A smile is not an artificial sign: (at least we dislike it very much when it assumes this character:) we are irresistibly impelled, by the constitution of our nature, to express certain feelings by certain modifications of the features.

> *Format enim natura prius nos intus ad omnem*
> *Fortunarum habitum; juvat, aut impellit ad iram,*
> *Aut ad humum mærore gravi deducit et angit:*
> *Post effert animi motus interprete lingua.*

There is nothing left to accident here: every thing is fixed and determined; and a man generally makes a very awkward figure when he endeavours to exhibit the signs of emotions different from those which he actually feels. Yet, can any possible connection be traced between the feelings of happiness, or grief, or anger, and a particular modification of the muscles of the face? It is to no purpose that we are told, that certain emotions put in action certain muscles about the heart, we shall say; and that these muscles affect others which, in their turn, communicate the impulse, till the result is depicted in the human countenance. This is, no doubt, a very interesting subject of study to the anatomist or physiologist; but it is perfectly useless to the metaphysician who is enquiring into the origin of sensations, and the connection between natural organs and a thinking spiritual substance. All that the anatomist does is to describe the machinery; the metaphysician endeavours to ascertain the principle of motion.

But, then, some metaphysicians affirm that the perception of objects is not immediate; but that the rapidity with which we interpret the signs is the result of early and deep-rooted association. This is the opinion of Hartley and of many others. Dr. Porterfield says, that "it is not the external sun and moon which are in the heavens that our mind perceives, but only their image or representation impressed on the *sensorium*." Perhaps we do not perceive any of the objects of nature as they really are; yet this does not interfere with our ready and rapid apprehension of them. The picture of objects always appears inverted on the *retina*, yet we always perceive them in their right posture. Philosophers and physiologists have puzzled themselves exceedingly to account for this; but all to no purpose. They talk of the rays which proceed from the object, crossing each other in the eye, so that those which come from the upper part of the object strike on the under part of the *retina*, and *vice versa;* and therefore they imagine that we perceive objects in their right posture, in the same manner as we would judge an object which strikes the roof of a room to come from below. This is egregious trifling; was any man alive ever sensible of any crossing of the rays, or of any impulse either on the upper or under part of the posterior coat of the eye? The truth is, that in tracing the image to the *retina*, we are attending only to one stage of the process. We can form no conception whatever of what takes place afterwards; nor can we conceive how it should be easier for the mind to apprehend the image of an object than the object itself.

It is said, indeed, that there must be a communication between the object and the mind. Correctly speaking, we can form no conception of any connection except between the outward object and the bodily senses. Hearing is produced by undulations or pulsations of the air on the ear; taste by the application of sapid substances to the palate; vision by a picture on the eye, &c. Here, then, we perceive an evident connection between external objects and the organs of sense: but still the distance between the impressions on our organs and the sensations of our minds is immeasurable; and we consider it as perfectly unphilosophical to talk of either an object or any image being present to the mind. Who can fix the locality of a spirit, or say that it can even be in contact with a material substance? Or how can a spiritual substance be affected by any thing but a spirit?

These are questions which no man can answer; yet we see that particular objects produce, with infallible certainty, particular sensations in our minds. But these impressions on our senses are merely signs established by the author of our nature to call our attention to objects which it is our interest to pursue or avoid, and which may promote or impair our happiness.

By following the train of our own conceptions, we have been led to some conclusions not very remote, we apprehend, from the opinions of Malebranche and of Leibnitz: for though their systems are professedly opposed to each other, we do not see that they differ widely on the point in question. But all that we mean to say is this, that after examining, with the utmost minuteness, the mechanism of the senses, and showing the organic affection which takes place when a sensation is produced, we are as far as ever from being able to connect mind with matter, or to ascertain the way in which they mutually affect each other. Such an intercourse, however, is established by the author of our nature: but there is no chance that we shall ever get behind the scenes, so as to be able to discover every part of the machinery, till *we have shuffled off this mortal coil;* and our souls are disengaged from the gross encumbrances, which at present clog and impede their operations.

All that we know for certain, is, that when impressions are communicated to the senses, they are at the same instant imparted to the mind: and we conclude that this is done *immediately*, how complicated soever the machinery may be which is put in motion by the external impression. When, for instance, we handle a cube, or a globe, we receive *immediate* intimation that we are handling an extended substance, distinct from our own bodies. There is not the most distant foundation for the supposition of any image being interposed to make the object apprehensible by the mind; and we do not see that it makes any material difference, though the objects be placed at a distance; they are still connected with the senses by certain sensible *intermedia*, which bring them into contact, when an immediate perception is produced in the mind. We conclude, then, without the smallest hesitation, that *external existence is the immediate object of perception*, and not the result of associations, or of the interposition of images or ideas, of which no man was ever sensible.

In short, we do not think that there ever was a philosophical dogma which, with such a slight foundation, exerted such influence over the human understanding.

It is, at least, as old as Plato, perfectly conformable to his poetical genius, which delighted in analogical and metaphorical illustrations. He supposes a man to be lying bound in a dark cave, into which some rays of light are admitted through an aperture. These rays fall on the side of the cave to which the eyes of the prisoner are directed. In the meantime, a number of persons or objects, in passing, intercept part of the light, and their shadows are cast on the opposite side of the cave. These shadows, and not the things themselves, are perceived by the prisoner. In the same manner, Plato conceived that the senses perceive not the things themselves, but only the images of them. It is evident that all this is mere fancy; yet we do not think that the doctrine of ideas has any better foundation to support it.

Descartes, like all the old philosophers, took it for granted, that what we perceive must be either in the mind itself or in the brain, to which the mind, as he supposed, is immediately present: for this purpose, he fixed the seat of the soul in the *pineal gland*. If objects are perceived in the mind, Hume argues fairly enough, that the mind must be extended; for we cannot conceive how the *idea* of extension, (which, according to Descartes and his followers, is an image of the original,) can ever be *in* an unextended substance. And, as for the *seat of the soul*, were not the subject now exploded, we would recommend it to the ridicule of the poet, rather than to the discussion of philosophers. At one time, however, it occupied no small space in their speculations, and is thus ridiculed by Prior in his *Alma*.

———————" Here Matthew said,
Alma in verse, in prose the mind
By Aristotle's pen defined,
Throughout the body squat or tall,
Is, *bona fide*, all in all.
And yet, slap dash, is all again
In every sinew, nerve, and vein;
Runs here and there, like Hamlet's ghost
While every where she rules the roast.
This system, Richard, we are told,
The men of Oxford firmly hold:
The Cambridge wits, you know, deny
With *ipse dixit* to comply.
They say, (for, in good truth, they speak
With small respect of that old Greek,)
That, putting all his words together,
'Tis three blue beans in one blue bladder.
Alma, they strenuously maintain,
Sits cock-horse on her throne, the brain;
And, from that seat of thought, dispenses
Her sovereign pleasure to the senses."

Dr. Reid had the honour to be the first who called in question the Cartesian doctrine of ideas; and, in our opinion, his success has been complete. We have adopted his conclusions without adhering to his train of argument; for we think his opinions need only to be known, to derive illustration from a thousand different sources. We make no pretensions, then, to any discoveries of our own on this subject: we were trained in his doctrines under his illustrious pupil; we therefore lay claim to nothing but the illustration and even this coincides in many instances, as might be expected, with that of Reid.

We have said that the impressions made on the senses are merely signs which the mind interprets with infallible certainty. These signs, Dr. Reid remarks, are the language of nature to man: and, as in many respects it has great affinity with the language of man to man, so particularly in this, that both are partly natural and original; partly acquired by custom. Our original or natural perceptions are analogous to the natural language of man to man; and our acquired perceptions are analogous to artificial language, which, in our mother tongue, is got very much in the same manner with our acquired perceptions. When we perceive that this is the taste of cyder, that of brandy; that this is the smell of an apple, that of an orange; that this is the noise of thunder, that the ringing of bells; this the sound of a coach passing, that the voice of a friend; these perceptions, and others of the same kind, are not original, they are acquired. But the perception which we have by touch of the hardness and softness of bodies; of their extension, figure, and motion, is not acquired, it is original.

" Experience teaches us, that certain impressions upon the body are constantly followed by certain sensations of the mind; and that, on the other hand, certain determinations of the mind are constantly followed by certain motions in the body; but we see not the chain that ties these things together. Who knows but their connection may be arbitrary, and owing to the will of our Maker?" Such are the words of Dr. Reid; and we think he need have no hesitation in declaring, that every thing which depends on the will of the Almighty, as sensation, and every thing else undoubtedly must, is most certainly arbitrary, and determined by nothing but his own free will. This is nearly an identical proposition: and it is certainly the most obvious of all truths, that whatever the Almighty does, he does it because he wills it. This is equally true of man: but there is this difference in the general result, that the will of Deity never can be influenced by extrinsic motives; for he is all-sufficient and independent; and contingent motives in his case are wholly incomprehensible. Every thing is different, in this respect, with regard to man; he does what he wills, but his will must necessary be influenced by various motives over which he has no control.

Those things which appear natural to us, must be arbitrary to God: we call that natural which continues to retain the qualities, and present the appearances which we have been accustomed to observe in it. We refer, then, both the natural signs of our sensations, and our power of interpreting them, to the will of our Creator, who had only to say, " Let such things be, and such qualities exist," and forthwith the connections which we see were established; which may be called *necessary connections*, inasmuch as they must necessarily continue till the will of the Almighty shall change or suspend them.

Dr. Reid farther observes, that " we know nothing of the machinery, by means of which every different impression upon the organ, nerves and brain, exhibits its corresponding sensation; or of the machinery by means of which each sensation exhibits its corresponding perception. We are inspired with the sensation, and we are inspired with the corresponding perception, by means unknown. And because the mind passes immediately from the sensation to the conception and belief of the object which we have in perception, in the same manner as it passes from signs to the things signified by them, we have therefore called our sensations *signs of external objects*."

We have stated the doctrine a little differently; and have made the impressions on the organs of sense *the* *signs* by which certain sensations in the mind are excited, and by which its attention is, at the same time, directed to the exciting cause. We might have had all the sensations which we now possess, those arising from touch excepted, without any knowledge of an external world. By the experiments first made by Cheselden, and subsequently confirmed by many others, it appears that visible objects, when first presented to the eye, do not appear *external* to it; they seem to be in it: they present merely a variously coloured picture to the mind. In the same manner, sound is a mere sensation; habit alone enables us to judge of the quarter from which it comes, and of its being referable to external causes. If any man will stand blind-folded in the middle of a room, and allow his most intimate acquaintances to walk repeatedly round him, without speaking, and afterwards stand still and address him, he will not know, for several trials, the position of the speaker. It is evident, too, that it is only by experience that we learn to refer smell to odoriferous particles, issuing from external bodies; and that we might have had the sensations of taste without the application of sapid substances to the palate; for nothing is more common than to have a particular taste in the mouth, without being able to ascribe it to any external cause. Nay, it is habit alone which makes us refer particular sensations to particular senses; and, were it not for this, we could have no conception of any existences but our own sensations; excepting always the sensations which arise from touch, and which lead us at once to the conception and knowledge of something external.

In short, we conceive the mind to possess in itself all those capabilities which are roused by an excitement applied to the senses; but we cannot tell how: this only we believe, that it is immediate and instantaneous, however complicated the machinery may be which is interposed. Who can tell how many muscles must be put in motion before a smile or a frown can be depicted on the human countenance? Yet the sensations of joy or anger are no sooner felt, than a visible portraiture of them is displayed on the countenance. To account for the explosion of gunpowder by the application of a spark of fire, would require a complete knowledge of pneumatic chemistry, and of the constitution and properties of the atmosphere: yet, notwithstanding of all this, the ignition and explosion appear simultaneous. So we believe it to be with the *impressions on the senses; the sensation* they produce; and the *perception* which accompanies it. In the case of touch they are simultaneous; and they soon become so, or appear to be so, with regard to the other senses; for as soon as we have learned that they are excited by external causes, which no man can avoid learning, the *impression, sensation*, and *perception*, are produced at one and the same time.

Perhaps we have gone far enough on the subject of *ideas*, as our object is merely to give our readers some notion of the questions generally agitated by metaphysicians; and, as far as in our power, to furnish them with the materials for forming clear conceptions, and accurate opinions respecting them. We have dwelt the longer on the doctrine of Reid respecting ideas, as his writings form, in fact, a new æra in the philosophy of mind in this country; we mean Scotland, for his works seem to be very little valued, or known in the southern division of the island. Indeed we cannot help thinking it a matter of regret, that the fame of Reid is now almost absorbed in that of his pupil Dugald Stewart; not that we think this philosopher unworthy to occupy the very highest rank among ancient or modern pneumatologists; but we are persuaded he himself will regret, should even his own fame obscure that of his master, whose merits and achievements in mental philosophy he has blazoned with so much eloquence and affection.

With regard to Mr. Stewart himself, we have only to say, that we consider him as the most elegant and judicious philosophical critic at present in existence. His merits, as yet, appear chiefly in explaining and expanding the views of his master, in separating what is salutary in other systems, from what is trifling or noxious, and in inspiring a conviction that it is possible to render the philosophy of mind both interesting and useful. To this praise we venture to add, that, of all living authors, he is the most accurate and most elegant writer of the English language. Our subjects of regret with regard to him are, that he is either too timid or too indolent; for, just when he has brought us to the brink of an original discussion, to which his powers are adapted, he puts us off with the promise of a separate dissertation on the subject. If he lives to redeem all his pledges, he will have no reason to complain of the brevity of human life; and the world will have reason to be thankful for so many additional sources of enjoyment.

We commenced this article, with stating the advantages arising from the study of metaphysical science; and we suspect there will be some who will think that we have been undermining our own position, by detailing the jarring, inconsistent, and uncertain speculations of metaphysicians. But, in truth, the advantage of metaphysical studies appears, not so much in the adoption of any particular system, or in adherence to any particular master, as in the habit of accurate mental analysis, and in correct investigation into the origin of our feelings, sentiments, and opinions. No man who has not been accustomed to such investigations can ever attain to any thing like accuracy in moral or intellectual researches: he may, indeed, be highly useful both to himself and others, by adhering to the rules and maxims prescribed by superior wisdom; but he must be a stranger to those refined pleasures which arise from contemplating the beautiful adaptation of means to ends, by which the mind approaches, as it were, a step nearer to the Deity.

The metaphysician may go wrong in his researches; but he is like the adventurous mariner, who explores seas unknown, and at his own risk points out the rocks, shoals and quicksands, which might endanger future voyagers. Perhaps he enters what he may reckon a secure harbour, or settles on what he supposes a fertile island; but if he does not discover his mistake in time, others are taught by his fate to avoid the experiments which have misled him.

There is no more uncertainty in metaphysics than in any other subject which is not founded on necessary truths. The same uncertainty occurs in all discussions respecting politics and religion; not that these subjects have no certain foundation, but from the impossibility of defining, with perfect accuracy, the conceptions of the mind respecting them; from which result differences of opinion, and sometimes fierce contentions: when, perhaps, all the while both parties are perfectly right according to the conceptions which they have formed, and the meaning which they have attached to particular words. There is no uncertainty, then, in the principles of morals; the uncertainty arises wholly out of misunderstanding on the part of the disputants, who frequently find, after long and furious wrangling, that they have been fighting about a phantom, and that there is, in reality, no difference of opinion between them.

The superiority of the mathematical sciences has always been supposed to consist in the superior accuracy of the definitions; it might have been said, in their infallible certainty: for they are all necessary truths. It has been said that the certainty of geometry arises solely from this,—that the geometrician measures and calculates only the ideas of his own mind, which he determines and circumscribes according to his own pleasure.* We do not think this an accurate view of the subject. The mind, we conceive, is as much conversant with realities in geometry, as in any other science; and the definitions employed, so far from being arbitrary, are all founded on necessary truths.

M de Maupertuis has placed this subject in a very clear point of view in an Essay, (in the twelfth volume of the *Transactions of the Berlin Academy*,) entitled, *Examen philosophique de la preuve de l'existence de Dieu*, &c. He says, that number and extension are the subjects of rigid demonstration; not because the mind has the power of forming gratuitous definitions, but because there is in these sciences a principle of what he calls *Replicability;* that is, we can divide number and quantity into any portions; we can halve them, quarter them, or raise them to any power, and still they will preserve, in all their divisions or multiplications, definite and necessary proportions.† Hence, we can proceed with infallible certainty in all our researches concerning them; and our most complicated calculations may all be reduced at last to identical propositions, such as *two and two are equal to four; and four is equal to two and two;* or to the metaphysical axiom, Whatever is, is.

Nothing of this kind can take place in metaphysical science: our sensations may, indeed, be stronger or weaker; but we cannot increase or diminish them in definite proportions. We cannot divide a sensation into halves and quarters; nor indicate the square root of a conception. We cannot even ascertain, that any definition which we can give, can convey to the mind of another, an accurate idea of our own conceptions and sensations.

From these circumstances, we think it must appear, that though there must necessarily be much diversity of opinion in morals, metaphysics, and religion, yet there is no reason whatever to suspect that they have not as sure a foundation as the demonstrative sciences. Amidst all the diversity of sentiment which occurs, who can divest himself of the moral and religious feelings which grow up with him from his birth, and influence his happiness and his hopes? And is it not a proof that these feelings have a sure and immoveable basis, when they continue to maintain their influence in spite of the jarring opinions which prevail respecting them; and the dangerous and absurd conclusions which are sometimes founded upon them?

We have already noticed incidentally, some of the metaphysical arguments for the existence of a God; but as this is a subject of the greatest importance, and involving some fundamental metaphysical principles, we shall treat it a little more in detail.

As the belief in the being of a God is the most important principle which can enter the human mind, so there is none which can be established by such a variety of proofs. In attempting to discover new arguments, or to display superior ingenuity, there can be no doubt that too much stress has often been laid on circumstances which are doubtful or inconclusive. The marks of design, of wisdom, power, and goodness, displayed in the works of nature, are generally supposed to afford both the most obvious and the most satisfactory evidence of the existence of an infinite and eternal cause. The Sacred Scriptures often illustrate this subject in very beautiful and sublime language, not so much to produce the belief of a God, as to excite feelings of reverence and adoration at the contemplation of his works. Thus it is said, in the Psalms, that *the heavens declare the glory of God, and the firmament sheweth forth his handywork;* and the Apostle tells us, that *the invisible things of God are clearly seen, being understood by the things which are made.*

At the same time it must be confessed, that we are extremely apt to err in our speculations respecting final causes, and that the utmost caution is necessary in selecting instances, lest we fix on such as may be subject to challenge, and thus weaken an argument which, if judiciously managed, must be irresistible. We know no author who has handled this argument more successfully than Paley, in his *Natural Theology*, in which, from an examination of the various parts of the human frame, he has traced the clearest proofs of benevolence and wise design, and has shewn, at the same time, that any inconveniences or evils that may arise to the system are incidental, and form no part of the original plan.

We have no doubt, that the same reasoning is applicable in all the different departments of nature; though we are, in many instances, too ignorant to discover the wise adaptation of their several parts, and their mutual subserviency to promote the good of the general plan. We even see many things which puzzle and perplex us, and which we cannot reconcile with our limited views of expediency and wisdom. We may, for instance, admire the wisdom displayed in the structure of a snake, or a scorpion, or a poisonous plant, or venemous insect; but then we are led to inquire, "why all this apparatus, in the case of things which are positively hurtful?" We suspect that it is quite impossible to give any thing like a rational system of theology from the light of nature. But if we admit that man is a fallen and sinful creature, and obnoxious to punishment, we can perceive a reason why he should be subjected to such scourges. They remind him of his delinquency; and they teach him

* Si le geometre est moins sujet a broncher, que le philosophe, c'est uniquement parce qu'il ne mesure et ne calcule que des idees, les quelles il determine et circonscrit lui meme a sa phantasie. *Mem. sur appercep.* &c par M. Merian.

† He states also another reason for the superior clearness with which we discern mathematical truths. Our other perceptions are confined to one sense. The ear, the nose, the palate, &c. do not interfere with the provinces of each other; they have distinct perceptions appropriated to each. But the idea of number, and of *replicable* quantity, may enter the mind by each and all the senses. A being with only the sense of smell, would have the idea of number as soon as *two* different kinds of odours reached his nose: and so with the other senses.

caution, prudence, and preparation for death. Virgil, indeed, without the aids of which we speak, discovered a final cause for the existence of noxious animals, not very remote from that which we have suggested.

> Ille malum virus serpentibus addidit atris, &c.
> Ut varias usus meditando extunderet artes :
> Nec torpore gravi passus sua regna veterno.

The atheistical arguments, if arguments they can be called, are all extremely frivolous and absurd, equally destitute of foundation, either in metaphysics or in facts. Some of them are built on the apparent irregularity and want of benevolence, discernible in the arrangements of nature ; yet it is from the beautiful order and wise design manifest in all the parts of nature, which we have been enabled to examine, that the theist derives some of the most convincing evidences of a Supreme Creator and Governor of the universe. When we see, however, the two contending parties taking their stand on the same ground, and endeavouring to draw from the same source arguments to support their opposite systems, we may see the necessity of caution in selecting our instances, lest we fix on some point which may be untenable, or on some fact which may be imperfectly ascertained, or on some intention of the Author of nature of which we are not competent to judge.

But it is surely fair to conclude, that wisdom and benevolence prevail throughout the whole, since we have always discovered them in those parts which we have most thoroughly investigated, and that our ignorance of the uses and application of any of the objects of nature or arrangements of Providence, forms no ground whatever for arguing against them. Were this rule observed, atheism would be deprived of all its arguments drawn from the apparent imperfection and irregularity of the works of nature.

To obviate the arguments for the being of a God which Theists have drawn from the structure and preservation of animals, Atheists have alleged, that blind chance, or fate, or whatever else they may choose to call it, produced at first, an infinite number of animals of all possible natures, forms, and structures ; but that those only survived which *happened* to have the qualities and properties adapted for preservation. The animals without mouths, for instance, would soon perish ; those deprived of the organs of generation could not propagate, and wherever the structure necessary to the vital functions was imperfect, life would soon be extinguished ; the animals only which *happened* to be perfect could live and propagate. Atheism must be reduced to miserable shifts indeed, when it has been obliged to have recourse to such arguments. Perhaps they ought not to be answered in any other way, than by shewing that they are not only unfounded in fact, but directly opposed to every known fact in the constitution of nature. For where have we ever seen any instances of such promiscuous and casual productions ? Are there any who now believe in the production of animals by the solar heat acting on the slime of the Nile, independent of the usual process of generation ? If there are any such, they may be influenced by the atheistical hypothesis which we have stated ; but no man in his senses would attempt to argue with them, as they hold principles totally inconsistent with the known facts and analogy of nature.

But it may be demonstrated, on the soundest principles of metaphysics, that the hypothesis is absurd and impossible. For when did this *chance*, or fate, or whatever it was, begin to operate ? If it had a beginning, it must have had a cause : this is a metaphysical axiom ; and the man who denies it, is no more a subject of argument than he would be who should deny that two and two make four. If then, this *chance*, *fate*, &c. had a beginning, it cannot be the cause of any thing, since it is itself caused by something else.

But we are prepared to hear the Atheist affirm, that this principle of his is eternal, and had no beginning. On this supposition, then, it must eternally operate ; and what has been must always be, for to suppose any interruption in the continuity of eternity is absurd. But, according to the atheistical supposition, this eternal principle acted only once in a confused and random manner, and has ever since acted regularly and uniformly. Here, then, is an evident change, in an eternal, self-existent principle, which is also absurd ; for if change and chance be essential to it, they should operate always, which is not the case.

The philosophy of Epicurus is atheistical, though he himself, and many of his followers, admitted the existence of a God. But this was merely to save appearances, and to escape the inflictions of the law, which was particularly severe against Atheism in all the heathen states ; indeed, the prevailing error was quite of an opposite description, and ran into the extremes of Polytheism and Idolatry. This error, pernicious as it is, is, nevertheless, infinitely more excusable than Atheism : for Polytheism may easily arise out of wrong conceptions of the attributes of God, whilst Atheism can only spring out of the most criminal inattention to the evident displays of the divine power, goodness, and wisdom.

Epicurus and his followers, whilst they admitted a God, denied his providence, and endeavoured to shew how the world could be made without Him. This they achieved by the fortuitous concourse of atoms, which, moving from all eternity, were, at last, by some miraculous accident, jumbled into the present goodly order of things. (See Atomical Philosophy.) This hypothesis is too absurd to have any supporters in modern times, and yet it is as rational as any other system which excludes the agency of Deity in the formation and government of the universe.

Another Atheistical hypothesis is, that the present order of things is eternal, and that one thing has produced another in infinite succession. An infinite succession *a parte post*, might, in one sense, be admitted, for we can easily conceive an order established by the Almighty which shall never have an end. But an infinite succession *a parte ante*, is absurd, for it would imply that infinity is made up of finite parts, and that it may be increased or diminished, which is a contradiction. If the series of causes and effects was infinite a thousand years ago, it is more infinite now, for it has received numberless additions. Here, then, would be an infinity which is not yet infinite. Or, viewing it differently, if the infinite series was complete a thousand years ago, then, in that case, we have an infinity which is already terminated, which involves an absurdity.

But, leaving the absurdities and impieties of Atheism, let any man cast his eyes on the visible creation, and on the various objects of nature, and without entering into any speculations as to the uses and ends of particular parts, let him ask himself this plain question, " Whence arose this order of things?" To suppose them eternal, would be to make them self-existent, immutable, indestructible; in other words, it would be to suppose that they had a necessary existence, and that the very supposition of their destruction would involve an impossibility. But how ill do any of these attributes apply to any of the objects of the visible universe? Instead of being immutable, we see them every moment liable to change; instead of being indestructible, we have no difficulty in conceiving their utter annihilation: indeed, we cannot conceive how they should be kept from it, but by the sustaining influence of Him who created them, for God himself cannot make any thing independent of himself.

Whence, then, had the world its beginning? It could not exist without a cause; for this is the property of a self-existent and necessary being, which, as has already been seen, the world is not, neither could it be the cause of its own existence, for, in that case, it must have acted before it was, which is impossible. It must owe its existence, then, to a being, self-existent, uncreated, eternal: and this being we call God, who created all things by the word of his power, and who has informed us in the records of inspiration, that a time shall come when the elements shall melt with fervent heat, and all things shall be dissolved into their original non-entity, or moulded into new forms and modes of existence, by the *fiat* of the Almighty.

All the ancient philosophers held *creation*, in the sense in which it is now generally understood among Christians, to be impossible. It was an axiom with them, that *nothing can be produced out of nothing; nihil fit ex nihilo.* On this principle, all that they allowed to the agency of the Deity, was the arrangement of pre-existent materials, and the moulding of an external material substance into the form which it now exhibits in the visible universe. This is liable to all the objections which we have already stated. It gives to matter a necessary existence, and, of course, represents its destruction as impossible. The doctrine of Spinoza is the legitimate offspring of this axiom of the ancients. He saw, that to make matter eternal, was to invest it with the essential attributes of Deity; but, instead of being staggered by this consequence, he made it the foundation of his theological system; if that can be called theology which is founded on the motion of a material Deity. He held, that no being can communicate any thing but its own nature to another; taking it, therefore, for granted, that the material world exists, he thought that it followed, of course, that it must have proceeded from a material origin.

There cannot be a grosser mistake than to suppose, that the Supreme Being can be compared to any thing which we observe in the visible universe. Aristotle, though no great theologian, yet avoided such an unphilosophical notion as this. For, whilst he admitted that the Deity was the first mover of all things, he laid it down as an incontrovertible maxim that he himself was unmoved, *principii enim nulla est origo.* Instead of being essential to his nature to possess the qualities of any visible substance, his essence is to be conceived as directly opposite to every thing that is cognizable by our senses. Every object in nature may be increased or diminished, but God is infinite, and admits of neither increase nor diminution: every thing that we see is mutable, but *with God there is no variableness nor shadow of turning;* in short, his essential attributes cannot be imparted to any created being: the very idea of a *creature* excludes the possibility of such communication, for, if it is created, it cannot be self-existent and eternal. None of our faculties can enable us to form any thing like an adequate conception of the nature of God; nay, they necessarily lead us to form wrong conceptions of Him. We can judge of things only by comparison, by number, measure or weight. But to what shall we compare God? We may compare the flame of a candle to the light of the sun, or a grain of sand to the globe of the earth, or to the masses of matter which compose the heavenly bodies; for, however vast the difference may be, there must be definite proportions among all created things. But God is infinite, and cannot be compared with any object which we have ever seen, or with any standard which our minds have ever conceived. The only idea that we form of infinity is by adding continually, till the amount exceeds our powers of comprehension, and then we fancy that we have a conception of something which is infinite. But it is a contradiction in terms, as has already been shewn, to suppose an infinity constituted by the endless addition of finite parts.

This, however, we may know with certainty, that we daily see and feel the operations of an infinite eternal being, and this is sufficient for our purpose, and for inspiring confidence and hope, though the nature of God be unsearchable, and his ways past finding out. We imagine, indeed, that we can form some idea of the manner in which the Almighty actuates and pervades universal nature, by comparing it with the way in which the soul actuates the body, and communicates its influence to its various organs and members. This analogy or illustration has been employed in almost every country where any discussion has taken place respecting the nature and operations of the Supreme Being. Hence he was called the *anima mundi*, by the ancient philosophers; and the poets, taking up the same idea, represented all things as full of God. *Jovis omnia plena.*

It is perhaps a legitimate illustration to say, that as the soul actuates the body, so God actuates the frame of nature. But beyond this we cannot advance a step with safety; for we shall soon find that the comparison must utterly fail. Our souls and bodies are only a part of the general machinery of nature, (if we may use this expression,) put in motion and upheld by the hand of the eternal workman. We may, then, infer with infallible certainty, that he is wise, and powerful, and good; in the same manner as we can judge from effects, that these qualities may belong to human agents: but the motives which influence men to the practice of virtue can afford us no explanation of the counsels of God. He works in us to will and to do of his good pleasure; the motives which impel us to action are exceedingly various, and very often beyond our control: they are often entirely unforeseen; and the most important events in the history of our lives frequently arise out of circumstances unexpected, and apparently accidental. All this is entirely inapplicable to God. He acts of himself alone, and never can be influenced by external motives, since all things are ordered by him, and are dependent on him.

From what we have already said respecting the nature of God, we think it must follow by necessary consequence, that there can be but *one* God. One infinite being excludes the possibility of any other possessed of equal or independent power. Hence God, in order to give the Israelites the most impressive idea of the unity of his nature, made himself known to them by his attribute of *self-existence*. For when Moses asked his name, he commanded him to say to his countrymen, "*I am* hath sent me unto you."

As God is infinite, self-existent, and eternal, he is also unchangeable. Every change in any being is a proof of imperfection, even though the change should be for the better: for a being susceptible of improvement cannot be absolutely perfect. But *God is the same, and changeth not*. No addition can be made to his knowledge or happiness, he can therefore have no reason to wish to change: and as there is no power superior or equal to his own, there can be no necessity which can compel him to change. None of those circumstances which produce a change in human conduct can have the slightest influence with God. We are often compelled to change our purposes, because they have been planned in ignorance, and circumstances which we could not foresee have rendered them impracticable. The most pernicious of all absurdities would be laws and regulations which could not be altered. Such, we read, was the case with the laws of the ancient Medes and Persians; and the only consequence of such regulations must have been to obstruct the improvement of the human race in happiness and knowledge. But nothing can ever occur to induce God to alter his purposes; for they were not formed after the manner of the short-sighted plans of mortals. They are always founded at first in infinite wisdom, and with a perfect knowledge of every thing that is to come to pass, and therefore there can be no reason why they should ever be changed. When we see a nation at one time prosperous and successful, and at another discomfited and depressed, and when we ourselves experience alternate vicissitudes of gladness or sorrow, we must not suppose that these outward changes of fortune proceed from any change in the counsels of God. He has always the same object in view, viz. the happiness or improvement of men; and he adapts his dispensations to their circumstances, according as they need encouragement, correction, or assistance.

We have already alluded to the argument which Dr. Clarke employs to prove the existence of a God. It arose out of some sublime metaphysical ideas of Sir Isaac Newton, respecting the nature of the Supreme Being. He had said, *non est duratio et spatium, sed durat et adest*, &c. Dr. Clarke conceived, that in space and duration he had got hold of two qualities, which, as they could not belong to any created substance, must be attributes of the necessary self-existent being. We give the sum and substance of his doctrine in his own words. "The supposal of the existence of any thing whatever, necessarily includes a pre-supposition of the existence of space. Nothing can possibly be conceived to exist, without thereby pre-supposing space; which therefore I apprehend to be a property, or mode of the self-existent substance; and that, by being evidently necessary itself, it proves, that the substance of which it is a property must be also necessary."

We most willingly do justice to the many profound and enlightened views which occur in Dr. Clarke's *Demonstration of the Being and Attributes of God*: but we think his main argument rests on a false foundation. So far from space being necessary to the existence of every thing, mind, with its affections, has no relation to it: and, with the exception of the ideas which arise from touch, we might have had every other idea, feeling, and affection which can enter the human mind, without being so much as able to form an idea of space. Where was space when there was nothing else but the Deity? It was then a non-entity; and it is still so; never having had any actual existence; but possessing the *potentiality* of admitting the existence of every created thing. In short, space is a mere privation; and we might as well assign a real existence to silence, because it has the potentiality of admitting sound, or to darkness, which has the potentiality of receiving light, as ascribe reality to space, which has merely the capacity of admitting the existence of material substance. It has been said, that we cannot conceive the annihilation of space: annihilate matter, and we cannot conceive that space can have an existence. It exists only in our conceptions; and is as foreign to the nature of God, as the passions and feelings of men, which never can be predicated of the divine essence.

Mr. Locke says, that though a man were placed at the utmost conceivable verge of creation, yet he would still be able to thrust out his hand beyond himself: and hence he argues that space is infinite. It would be just as rational to say, that there are no limits to non-entity. God alone is infinite: and he has provided a theatre for the display of his infinite power; and to suppose any limits beyond which created substances could not exist, would be to limit the power of God.

We hope that we speak with sufficient reverence, when we say, that the infinite mind can have no idea of *time*, which arises solely from the succession of ideas in our own minds. No such succession can take place in the divine mind. With God, *a thousand years are as one day, and one day as a thousand years*. In the same manner, space has only a reference to our conceptions; and we view it as consisting of definite portions, added together without end. We can evidently divide it into parts; we can suppose any substance to be annihilated; and yet we can form a clear conception of the space which it occupied, and of the dimensions which this space possesses. But nothing which consists of definite parts and proportions can be a property of the Divine nature, which is without beginning, without end, and without limitation, infinite, immense, and omnipresent.

The moral arguments for the immortality of the soul will be found under the article *Moral Philosophy*. The metaphysical arguments for the soul's immortality are by no means so satisfactory as those which we have adduced to prove the existence of a God. The ancient metaphysicians generally admitted that the soul was immortal: but they inferred this from the doctrine of the soul's pre-existence, which was almost universally received among them. They saw, that if they admitted that the soul was created, they must instantly renounce the argument for its inherent immortality: for they held, that nothing which was created could lay claim to natural immortality. They supposed the soul to be an emanation from the Deity, or an excerpt from his substance, and that it would again be absorbed into his essence. This doctrine destroyed any profitable conclusions which might be deduced from the soul's immortality: for it went to annihilate personal identity, and virtually to set aside a state of punishment and reward. It was attended with other absurdities, which are thus stated by St. Augustine—

"Quid infelicius credi potest, quam Dei partem vapulare, cum puer vapulat? Jam vero partes Dei fieri lascivas, iniquas, impias, atque omnino damnabiles, quis ferre potest nisi qui prorsus insanit."

The only metaphysical argument, of any weight, for the immortality of the soul is, that as the soul cannot be affected by the vicissitudes which alter or decompose material substances, it can be destroyed only by annihilation: but we have never seen any thing like annihilation, even with regard to material substance—"Omnia mutantur, nihil interit:" of course we have much less reason to suspect the annihilation of the soul, which we have never seen subjected to any of the changes which produce such striking alterations in the appearance and qualities of matter.

But no doctrine is more completely established than the immortality of the soul, when we take into view the moral and religious arguments drawn from the capacities of the soul, and the general administration of God with regard to this lower world; and more especially when we attend to the instructions of that Divine Teacher *who has brought life and immortality to light*, and confirmed the doctrine by his own resurrection from the dead.

METASTASIO, Pietro Abate, the celebrated dramatist, was born at Rome on the 3d of January 1698.* His birth name was Trapassi. We shall immediately have occasion to mention the circumstance in consequence of which it was changed. His family had once been opulent, though reduced to poverty by gradual decline. His grandfather, Felician Trapassi, was one of the thirty inhabitants of Assisi, to whom the freedom of the city belonged. The father of the poet, Felici Trapassi, was however unable to subsist in his native place, and enlisted for a soldier in the regiment of Corsi. He soon afterwards married Francesca Galasti, of Bologna, by whom he had many children. The poet was their second son. Felice, whilst he was in garrison, added something to the scanty pay of a soldier towards the maintenance of a family, by becoming an amanuensis; and having fulfilled his military service, and by extreme industry and economy saved a little money, he entered into partnership with a shopkeeper at Rome, for the sale of goods which belong to what the Romans call l'arte bianca, consisting of oil, flour, pastry, and other culinary materials. Having prospered tolerably in this kind of merchandise, he placed his two eldest sons, Leopoldo and Pietro at a grammar school. Pietro (our subject) soon discovered an extraordinary quickness for learning, and a disposition for poetry. He could turn extempore verses on any given subject before he was ten years of age. This faculty he used to exercise after school hours at his father's shop, where crowds would assemble in the streets to hear the young improvisatori. During one of those tuneful fits, the learned civilian and critic, Gravina, accidentally passed, and was so struck by the harmony of the child's verses, and the sweetness of his voice, as well as by the liveliness of the thoughts which he threw out "*al improvista*," either on persons who stood near him, or any subject of their suggesting, that he stopt to admire him, and offered him money. The polite refusal of the little bard to accept of his donation increased his admiration of him—he resolved to adopt him, and went immediately to solicit the consent of his parents for that purpose. As the civilian did not propose to take him from Rome, his father saw no necessity for refusing the proffered patronage, and the next morning Pietro was consigned to Gravina's care, who gave him the Greek name of Metastasio, as *μεταστασις*, *mutatio*, seemed at once to express his former name of Trapassi, and his new situation as an adopted child.

It seems at first sight rather inconsistent, that his patron, who had adopted him on account of his poetry, should have destined him to a study so unpropitious to poetry as that of the law; but Gravina was himself a lawyer; and, excepting the church, there was no other profession by which emoluments and honours could be then attained. At first, Metastasio was set to the perusal of pandects, decrees, and edicts—he nevertheless read the poets, by Gravina's permission, particularly Ariosto and Homer; and having, at the age of fourteen, produced his tragedy of Giustino, an astonishing work for a boy, though Metastasio afterwards regretted its appearance among his riper works; his patron not only tolerated but encouraged his poetical bias. Gravina took him, when he was 18, to Naples, expressly to afford him an opportunity of singing extempore with the most celebrated improvisatori at that time in Italy. When he appeared in Naples, he soon became an universal favourite. Nothing was to be heard of but his beautiful extemporaneous verses, which his hearers carried away in their memory—the grace and dignity of his elocution—and the inspired expression of his countenance.

With his poetical pursuits, he still continued the study of the law; and in order to obtain a passport through the only other promising road to preferment at Rome, he took the minor orders of priesthood, by the advice of his affectionate master. At 20 years of age he lost his patron Gravina, who died, aged 54, leaving behind him the character of a moderate poet and orator, but of great learning and classical knowledge, and considerable acuteness in criticism, though not unblemished by asperity. He rendered his name more celebrated by protecting Metastasio than by all the works of his own pen. The benefit of his influence on Metastasio's taste has been doubted, for he was a precisian in his ideas of classical purity, and it is supposed that if he had lived, his advice might have cramped his pupil's genius with rules of Greek art, and implicit imitation. However this may be, Metastasio's expressions of grief for his loss, which were strongly conveyed in poetical effusions, were never suspected of being insincere, though his mourning for him was that of an heir, which is sometimes so ludicrously doubtful,—for Gravina, faithful to his promise of treating him as his own child, bequeathed to him 15,000 Roman crowns, an excellent library, rich furniture, and a small estate in the kingdom of Naples. The specie alone, (equal to between three and four thousand pounds,) was, according to the value of money in those days, a sufficient independence; but among the lessons which his patron had taught him, he seems to have forgotten those of worldly wisdom. His legacy was soon spent, not indeed in vicious courses, but in the munificence of good cheer which he shewed to the admirers of his poetry and the frequenters of his table. In two years

* Dr. Burney (life of Metastasio) says the 6th of January. We follow the date of the life prefixed to the Florentine edition of the poet's works.

only an insignificant landed property remained; but though his fall was like Timon's, he had nothing of the misanthrope in his bland and benevolent disposition. At two and twenty, he set himself to renew the study of the law as a profession; and, as if he had resolved to secure himself against the seduction of the muses, he placed himself under an advocate of the name of Paglietti, a man who is described as "all law," a bitter enemy to poetry—one who hated the sound of verse, and the very sight of a poet; and was mercilessly intolerant of the slightest deviation from worldly prudence. One may figure a whimsical scene, in conceiving the shrewd and suspicious lawyer receiving such a noviciate, a youth already known and celebrated for poetical genius, but, with his fortune spent, obliged to determine in earnest that he would prosecute his legal studies. The assiduity of Metastasio is said to have at first inspired Paglietti himself with confidence, that he was thoroughly weaned from poetry; and we are told, that many who had before admired his verses, now regarded the rapidity of his progress in legal knowledge with still greater astonishment; but this change was an effort against nature, and could not continue. At the end of a year, we find him making a sly breach of his contract with the rugged advocate, by writing an epithalamium of 100 octave stanzas, at the instigation of the Countess of Althau. Then came his drama of *Endymion*, under the same sedative influence. The viceroy of Naples next prevailed on him to write the drama of the *Garden of the Hesperides*, on a promise that it should be kept a profound secret from his inexorable lawyer. His next drama was *Angelica*, the plot of which is taken from Ariosto. The poems which he produced at Naples were universally admired, particularly the *Gardens of the Hesperides*, but none felt the beauties of that drama so forcibly as Signora Marianna Benti Bulgarini, commonly called the *Romanina*, the greatest female singer and actress of her time, who performed the part of Venus in that piece, and was so enchanted with the poetry, that she would not rest till she was introduced to the acquaintance of the author. She felt, on seeing him, (says his biographer), an uncommon regard for him, and it was believed to be mutual. Meanwhile his legal friend Paglietti did not regard him by any means with the same pleasant looks as the actress his admirer, the *Romanina*. His poetical reputation was now blazoned abroad; and his disgust at the law, added to the severity of the old advocate, soon became sufficiently strong to make him wish to abandon the profession. Meanwhile the Romanina pressed him to take up his residence under her roof, and her husband joined in the same request. Metastasio was not insensible to the apparent indecorum of quitting a grave profession, as well as of laying himself under obligations to the family of Bulgarini; but, after a struggle in his own mind, he gave way to his love of poetry and leisure, and possibly also to his partiality for the lady, and accepted the invitation. To this proceeding, whatever may be thought of his motives, the world was perhaps indebted for the direction of his exquisite genius into its proper channel.

At the request of the Romanina, he wrote his "*Didone Abbandonata*," which was perhaps the first perfect musical drama that ever graced the Italian stage. The Romanina was a great actress, and a good judge of dramatic poetry, and Metastasio was obliged to her for suggesting the finest situations in his *Didone*. She was thought, with the exception of Mingotti, to be the only instance ever known of a female singer who had studied stage effect as well as harmony, sufficiently to enlighten the author of the words which she sung, as well as the composer of the music. The celebrity of the *Didone* occasioned its being set by the best composers of the time, for the other principal theatres of Italy, and it brought the author a considerable pecuniary reward.

In 1727, the Romanina having fulfilled all her theatrical engagements at Naples, was ready to return to her native city of Rome, provided her beloved poet would accompany her. Metastasio hesitated for some time, but at length consented, on condition that, in return for the hospitality which he had received under her roof at Naples, she and her family would consent to be his guests at Rome, where the relatives of Metastasio still resided. He therefore wrote to his agents to procure a house for the reception of his two families of the Trapassi and Bulgarini; and from the time of his arrival in that city, till his departure for Germany, they all lived under the same roof. The Romanina, as more accustomed to the superintendance of a family, managed the household; the rest attended to their own pursuits; while Metastasio received his visitors, wrote his verses, and increased his celibrity.

He finished several operas during his residence at Rome, as the "*Catone in Utica*," Egio, Semiramide Reconnosciuta, Artaserse and Alessandro nelle Indie, and his reputation continued to increase, not only in Italy, but spread beyond the Alps. But with all the praises which he acquired, it does not appear that he reaped much profit from his labours; and though he could not be said to be in necessitous circumstances, with his generous friend's purse at his command, he was poor, and surrounded by barren prospects compared with the claims which he had upon the gratitude of his country, as the restorer of her poetry, and as the greatest living ornament of her language. He had invited the Romanina to be his guest, but was obliged to be indebted to her liberality. She tried to console him with the most affectionate appeals to his fortitude, but his spirit, though naturally cheerful, began to sink into gloom and despondency. His affairs were in this unpromising state, when, in 1729, he received an invitation from the Court of Vienna to come and reside there as coadjutor to Apostolo Zeno, the imperial laureate. His pension was to be three thousand florins (L.300) a year. The offer was the more flattering, that it came in consequence of the recommendation of Zeno himself, who had enjoyed the laurel since the year 1718. His chief employment had been to furnish lyrical dramas for the imperial theatre, and they were reckoned the best dramas of the kind which the Italian language could boast of, before those of Metastasio. Zeno, declining in health and years, most honourably recommended a substitute for himself in this employment, who, he must have clearly foreseen, would eclipse his own poetical memory.

On quitting Rome for the imperial capital, Metastasio consigned the care of all his effects and concerns to his zealous friend the Romanina, who willingly took charge of his little places, and of the sums of money which he left behind him for the support of his father. He arrived in Vienna the 30th of July, 1730. The first regular opera which he produced for the imperial theatre was "Adriano in Siria," which was set to music by Caldara. Of its success we have no account; but we may conjecture that it was well received, from the favour which was shown to it by the rest of Europe. In one of his letters to Marianna Bulgarini, he gives a pleasing account of the reception of "Demetrio," the second opera which he composed in Vienna. The applause, he says, was such as the oldest people never remembered having been given to any theatrical piece. The audience repeated parts of it in conversation as if it had been German. He had not only been successful, but had conquered the envy attending on success; and "those," he says, "who were before his enemies, are now become his apostles." His correspondence with Romanina continued to detail to her the successive reception of his pieces, and the other incidents of his life, till no great time before her death, which took place in 1734. She manifested her attachment by beqeathing to him all her possessions after the decease of her husband, to the amount of 25 000 crowns; but Metastasio, with much rectitude and propriety, declined the bequest. Inconsistent as it may seem with our ideas of law and decorum, the legality of this will is not questioned by any of his Italian biographers; and his renunciation of it is spoken of by them all as a most disinterested sacrifice. Of the nature of his connection with the Romanina, it is no great breach of charity to judge, that it was not probably quite platonic. The circumstance of her husband residing in the same house with them, both at Naples and Rome, might be thought indications of conjugal fidelity; but a chaste actress and opera singer is a still more uncommon phenomenon in Italy than in England. The female Italian opera singers, as Dr. Burney observes, generally find it convenient to have a nominal husband, who will fight their battles, and contend with the impressario, or manager of the opera. In the course of their correspondence, it appears as if the Romanina was at one time anxious to go to Vienna as a singer, and suspected Metastasio of not speaking openly on the subject. It was thought that he was fearful of the effect which her arrival might have had on his own reputation, as the Emperor Charles VI. was a prince of very rigid ideas of decorum. Yet, after all, it is not easy to part, on very harsh terms, with the name and memory of the woman who solaced the heart, and cherished the genius of Metastasio. Something may be allowed for the general manners of her country and her vocation. She was no ordinary person; she made no vulgar choice in her affection; and was neither mercenary nor inconstant in preserving it. The age at which she died is not precisely known; but she was probably older than Metastasio, having attained to the zenith of her reputation as a singer in Genoa in 1712. Metastasio speaks with deep grief for her death to those with whom it was not his interest to be ostentatious of such feelings. In a letter to his brother, he says—"Poor Marianna will never return; and I believe that the rest of my life will be insipid and sorrowful." It has been already noticed, that in early life he took the minor orders of priesthood. In one of his letters to his female friend, he mentions the death of a certain abate in Sicily, to whose vacant abbey he would have wished to succeed; but did not know in what diocese it was situated, or whether it was requisite that the candidate should be a regular ecclesiastic. It appears from other letters, that although he wished for secular perferment in the church, he had no intention to be an ecclesiastic "*in sacris*."

His course of life after his removal to Vienna, was little varied by other events than the successive production of his operas. In 1738, he was, without solicitation on his part, complimented by the city of Asisi with a patent of nobility. His appointment of laureate, and the profits of his compositions, enabled him to support a respectable appearance in society, and to live with all the comforts necessary to his retired and moderate habits. It may be suspected, however, that he was obliged, for many years, to cherish retired and moderate habits from necessity as much as choice; nor does he write to his friends at all times with unqualified satisfaction about his pecuniary affairs. "Charles VI.," he says in a letter to a friend, "as a reward for my long services, and to make up for my unpaid salary, granted me a thousand crowns in Sicily on a bishoprick or benefice in that kingdom; but all the bishops, abbots, and beneficed clergy became from that time immortal, and the kingdom was lost before I had received a penny The treasurership of Cosenza in Calabria becoming vacant, my august patron, remembering my unpaid arrears, destined it for me. I took possession—spent more than 800 ducats of my own money in fees and other expences; but before I had begun to to reap the first crop, the Spaniards entered the kingdom, and I remained with my patent in my hand, ready for curling my hair, or folding up sugar plums."

The Empress Queen, he farther relates to his correspondent, impoverished by a seven years' war, was obliged to diminish the salaries of her servants. To console him for this diminution, and for his other losses, she assigned him 1500 florins in Milan; but at the end of five years the promise was unfulfilled; and after fifteen years service he found himself in a worse state than when he had left his native country. This was undoubtedly a faithful picture of his affairs at one period of his residence in Germany. It is clear, however, that he must have ultimately saved money at Vienna in the course of his long life, from the sums which he left at his death.

These particulars of his private history are contained in his correspondence with the celebrated singer Farinelli. A friendship subsisted between our poet and that musician for fifty years, after they were separated and established in the service of different monarchs in the two most remote capitals of Europe. The poet and musician were nearly of the same age, and began their public career in the city of Naples at the same time. They regarded each other as twins of public favour, brought to light at the same birth, and united in one common interest. Metastasio never imagined his poetry injured by Farinelli's too florid style of singing; and such was his fraternal affection for his "*caro gemello*," that he overlooked or forgot the want of simplicity, action, and pathos in his singing so entirely, as to censure young performers for these defects in his letters to Farinelli.*

* Farinelli (whose voice was found to operate on the disordered mind of Philip V. like the harp of David on the evil spirit of Saul,) was retained in the service of the Spanish court with a pension of 300*l.* a-year, which, after Philip V. died, was continued under his successor.

The tenor of his life was uniform and placid at Vienna, if not remarkably happy; and whatever disturbance the absence and remembrance of Marianna may have given him, he never seems to have fallen again in love. "You believe me," he says in one of his letters to a friend, "in danger here from the charms of some tranquil Teutonic beauty; how mistaken you are. Here, love and hatred never disturb the sleep of any mortal: here the body cares very little for the affairs of the mind; at night you may be a favourite, and in the morning unknown. Eagerness, agitation, solicitude, little quarrels, reconciliations, gratitude, vengeance, &c. all that gives terror or pleasure in the commerce of delicate souls, is here thought ridiculous, or fit only for the embellishments of romances. It is incredible to what a pitch of indolence the placid nymphs of this place are arrived. I should despair of finding one that would relinquish a game at piquet for the loss or death of her dearest lover. There are many who would think the turning aside from their sampler among the most mysterious excesses of genius." He divided his apartments with the family of Signor Martinez, the imperial librarian, whose sister, brought up from the cradle by the poet, and highly accomplished in literature as well as in music, devoted herself with filial attachment to his amusement. From the period of his fixing in this intimacy with the family of Martinez, he acquired a habit of dividing his time so regularly, that a single day became something like a miniature of his life; and he was often in jest, though with great justice, compared to a clock. In the morning he went always at the same hour to hear mass at the church of the Capuchins; from thence he went to visit the Countess of Althau, with whom, his Italian biographer says, that he regularly spent his time from eleven till two in the morning, and from eight till ten in the evening; and after her death he spent the same allotted hours with his friend Perlas, the canon of Breslaw. We must suppose that he met at that lady's house the circle of friends to whose society he was chiefly attached. He rose, took his meals, and went to bed always at a stated hour. At six in the evening he received at home the Sardinian minister and Baron Hagen, the president of the imperial Aulic council. With these friends, he spent his time till eight, usually reading the Greek and Latin classics in chronological order. In the intervals of the day he wrote his verses and his letters. When he had finished his writing, he never left a scrap of paper on the table. He was in short such a lover of order in all his ways, that he used to say jocularly that he feared Hell chiefly besause it was a place of utter disorder, and because he understood that in the infernal regions "nullus ordo sed sempeternes horror inhabitat." He was accused of bring finical in his person, from his attachment to odoriferous washes, and delicate soaps and pomatums. In his dress he was excessively neat and simple. He had a frailty in his advanced years of being averse to declare his age, and was not fond of alluding to his humble parentage. Having never had the small-pox, he could not bear to hear the word mentioned; and when Lewis XV. died of that distemper, not only that circumstance, but even every thing concerning the Court of France, were forbidden topics in his presence. This weakness was the result of the uncommon dread of death, with which he was so tormented, that when any of his friends were given over, he never inquired more about them, nor was willing to hear their names mentioned. These were foibles in a character upon the whole highly estimable; for if not possessed of the strong and active virtues, he was perfectly free from jealousy, envy, malignity, and the selfish passions. In the April of 1782, having attained his 84th year, he was suddenly seized with a fever, which for some time made him delirious; but on recovering his senses he received the sacrament with symptoms of devout sensibility, which drew tears from the surrounding spectators; he also had the Apostolic benediction pronounced upon him in the article of death. This benediction was sent to him from Pope Pius VI., who was then at Vienna, by the Nuncio Garampi. He was buried with great funeral solemnity by his principal heir, Signor Joseph Martinez, to whom he left his house and library, and about 100,000 florins. A remaining, though small portion of his fortune, went to his sisters.

Metastasio was of middle stature, rather inclined to be large, but well proportioned in his person, with fine dark eyes, an aquiline nose, a well-shaped mouth, and fresh complexion; and, even at his advanced age, never wore glasses. Dr. Burney found him, at 72, looking like a man of 50, and the handsomest person for his age he had ever seen. On his features, he says, was painted all the genius, goodness, and propriety, which characterise his writings. He was cautious and modest in his intercourse, and so polite that he was seldom known to contradict any body in conversation.

Our limits necessarily oblige us to give a general character, and not an analysis, of the works of Metastasio. They contain, besides his poetry, a number of letters to friends, which were published after his death, and some reflections on the poetics of Aristotle. Gravina had taken care that he should be a good classical scholar, and he had studied with some depth the principles of his own art. He has left also some poetical versions from Horace and Juvenal. He composed eight-and-twenty regular operas, without reckoning a number of short pieces and entertainments, containing both airs and recitatives, like his greater operas, and often animated with theatrical action. His subjects are taken indifferently from mythology and history; and deal not only with antiquity, but, in one instance, with the middle ages, in the romantic and chivalrous piece of Rogero. This grand variety of ages, and countries, and manners, not only gives much scope for theatrical decoration in the representation of his pieces, but prompts the reader's imagination, even without witnessing their exhibition, to form rich and numerous conceptions of scenery and spectacle, and furnishes the poet's own fancy with a wealth of local imagery. With all this wide field of subjects, however, Metastasio is far from exhibiting a fertile diversity of human characters, interests, and passions; nor has he even attempted to be a great painter of nature and history. The cause of this deficiency may have partly lain in the frame of his genius, and partly in the nature of the opera, to which the temperament of his genius, by long habit, conformed itself. His soul, as a poet, was, no doubt, fraught with impassioned feelings, and with high forms and conceptions of the sublime and beautiful; but he had not, perhaps, from nature, a profound or daring character of thought; or, at all events, if he had it, he could not exercise it in the soft, voluptuous, and abstracted reveries of the opera. He devoted himself to the musical drama with an exquisite feeling of music; and, where poetry is incorporated with music, however enchanting their united effect may be, something of the independent and excursive vigour of the latter will necessarily be sacrificed. The enchantment which we experience from hearing some noble war-song, or affecting strain of tender passion, powerfully sung, may seem for a moment to throw a doubt upon this truth. We are apt to feel, in such instances, that poetry and music are natural, and ought to be inseparable allies. And we are right in thus appreciating the magic reciprocity which is here exchanged between the two sister arts, when it extends no farther than to a simple burst of feeling, or the recitation of a short and simple story; for music can express passion, and powerfully aid the verbal expression of passion. But when poetry extends to the unfolding of complicated situations, to dialogue, and diversified descriptions of life, it leaves the expressive powers of music behind it; and if it accommodates itself to musical expression, it must lose by the accommodation. Music cannot paint manners, but would degenerate to burlesque and mimicry, if it attempted to do so. The opera poet, therefore, whose aim is to give his poetry that mould alone to which musical expression can cling, and that beauty alone which music can heighten and adorn, though he may bring the passions into play, and though he may be rich, ideal, and persuasive, cannot carry into imitation that boldness and truth, which make the drama "*hold up, as it were, a mirror to nature.*"

Metastasio, the finest genius who ever attempted the musical drama, illustrates this theory in his whole theatre. His characters are all general and abstracted representations of human nature. They have individual names, but not individual natures; they burn with passion; they are exalted by virtue or debased by vice; but are monotonously good or bad, without the particular and minute traits which make the pictures of human beings illusive semblances of reality. The hero of one age and country is exactly the same with the hero of another. They are virtues and vices personified, and in the extreme; they are defective in physiognomy. Yet, if we weigh Metastasio, not by his generic but specific worth in the drama, as a writer of operas, and not of tragedies, we shall find room for almost unqualified admiration. His operas are, on the whole, in so far exquisite dramas, that the story which they tell is managed with classical and skilful arrangement; their plots are striking, interesting, and well adjusted; the story is irresistibly captivating, fraught with grandeur and fire, as well as tenderness of passion. Love, loyalty, and patriotism, are eloquently expressed; and the harmony and diction, both of air and recitative, are supported with exquisite power and simplicity. His language is so perspicuous as to be almost as intelligible to foreigners as prose itself. His nine dramas the most esteemed, are those which he composed during the ten first years of his residence at Vienna. Issipile, Olimpiade, Demophoonte, Laclemenza di Tito, Achille in Teiro, Semirami de Riconosciuto, Temistocle, Zenobia, and Regolo. In our own opinion, the tenderness and luxuriance of feeling in Demetrio is equal to any thing in his works, and almost unrivalled in the drama. The third scene of the third act of Demetrio is peculiarly touching, where Cleonice, the princess of Egypt, who had been induced, by a false sense of honour, to give up her lover Alcestes, when repentance seizes her, when she finds herself unable to support a longer struggle against affection, and overtakes Alcestes on the sea-shore, in the moment of his embarkation. The eloquence of love was never more romantic and beautiful, than in her speech in that scene which begins—

> "*Nil tuo povero albergo*
> *Qu'ella pace godio, che in regio tetto*
> *Lunge de te quisto mio cor non gode.*"

Metastasio is eminently the poet of love, and, in general, very happy in delineating noble and amiable sentiments. It is astonishing how much *naive*, and simple feeling, and natural language, he has thrown into the most artificial department of the drama; with how little constraint he moves in lyrical poetry, and with what artless, unaffected language, he unites the richest ornaments of imagination. In the opera, he is a poet without models, and without rivals. (*n*)

METELIN, anciently Mytelene and Lesbos, an island in the Mediterranean, at the mouth of the Gulf of Adramyti, on the south-west coast of Asia Minor.

This island is of a triangular figure: its precise dimensions are not ascertained; but in so far as we can collect, it seems about 42 miles in extreme length from north-west to south-east, 26 in extreme breadth, and the superfices probably may be computed at 500 square miles. Several rocky flats environing it are conjectured to have been once an integral part of Metelin, and some have supposed that an ancient concussion of nature rent the island itself from the neighbouring continent. The intermediate channels between two sides of it and the Asiatic coast, are nine or ten miles wide, with 50 or 60 fathoms of water.

There are no rivers here, but mountain torrents from the rains; numerous fountains, and many hot springs of different qualities, to which valetudinarians resort at all seasons, both for drinking and bathing. The southern coast is penetrated by two canals, each terminating in a spacious basin, forming two excellent and secure harbours, which are separated by the lofty Mount Olympus. Of these Port Caloni is the larger, but not so much frequented as the other Port Hiero, or Olisiere, lying towards the south-east extremity of the island. Traders repair hither during the whole year for cargoes of oil, and foreign navigators take shelter in it when adverse winds oppose their access to the Gulf of Smyrna.

The face of Metelin is mountainous: one chain of hills traverses the island in a longitudinal direction, and is intersected by another. Volcanic and calcareous productions abound. Granitic rocks on each side of the two channels, dividing it from the continent, are cemented by a calcareous substance; and among the petrifactions which occur at Port Sigri, the western extremity, are entire trunks of trees. Some parts of the surface of the earth are covered with a hard shining stony incrustation.

The climate is very fine; it rarely freezes during winter, and the summer heats are tempered by breezes from the sea. The island, nevertheless, is exposed to sudden storms from the Asiatic mountains, and towards the south coast it is insalubrious. Great mortality prevails in certain seasons; and whole villages are said to be occupied by leprous persons. Hippocrates celebrates the beneficial effects of the Lesbian climate on the body, and Demetrius Phalerius conceives that it invigorates the mind.

The ground is clothed with perpetual verdure, and the most luxuriant vegetation: almost all the mountains are well wooded, and exhibit a great variety of plants. Vineyards hang on the declivities of the hills, for the soil is friendly to the vine; and extensive plantations of olives afford an abundant produce. The ancients celebrated the quality of the Lesbian wine, but at present it is both rare and inferior, partly from the unskilfulness of the inhabitants, and partly because the grapes are converted to raisins, and also employed by the Greeks for making brandy. Neither the grain nor live stock are in sufficient quantity for home consumption. Horace speaks of Lesbian flour whiter than snow; and wool was formerly an article of export. The chief products, natural and artificial, of the present day, are about 50 000 or 60,000 quintals of olive oil yearly, most of which is carried to Constantinople; wood for shipbuilding, and pitch extracted from pines, for the same purpose. Nothing but pine is said to be used in the construction of the vessels, which are very light, and last ten or twelve years. Pococke mentions a manufacture of stuffs made of silk and flax, at a place called Peribole.

Considerable trade was carried on with France formerly: the French had a consul, and the English a vice-consul: but the former seems to have been withdrawn when it was ascertained that the oil of the Morea and of Candia could be obtained at a cheaper rate.

It is computed that Metelin contains about 40,000 inhabitants, consisting of Turks and Greeks in equal proportions, and a few Jewish families. The women are very handsome, with fine large expressive eyes and a beautiful complexion, which, however, they disfigure with paint; and they shave off part of the eye-brow, replacing it by an artificial one, connecting the remainder with the hair at each temple. The ancient Lesbian females are said to have had a public competition for the palm of beauty, which was adjudged by young men in the fane of Juno. But such contests do not seem to have been favourable to morals, as the people were considered dissolute: and a traveller of the last century remarks, that "the women have no better character for their chastity, nor the men for their sobriety, than in former times." In manners the modern females are rather masculine; they do not shun the gaze of strangers; they enjoy an uncommon portion of liberty, and even assume a paramount authority in all domestic arrangements.

Until lately, a remarkable deviation from the common customs of mankind prevailed regarding the law of succession here. The eldest daughter inherited the whole fortune of the family, while all the other children, male and female, were left entirely destitute. If there were only two daughters, the younger obtained no succession; and when the elder married, she remained in a state of subservience to her, wearing a particular habit, and attending her as a domestic. If the family consisted of more than two, this became the lot of the immediate younger daughter always, as her immediate elder sister married. Farther, it appears that the whole family possessions were transferred to the eldest daughter on her marriage, whereby she and her husband were kept in affluence, and her parents were reduced to an indigent condition, "and we ourselves," says the Earl of Charlemont, "have frequently been shown the eldest daughter parading through the town in the greatest splendour, while her mother and sister followed her as servants, and made a melancholy part of the attendant train." Something similar may be traced among various ancient countries; and there are some even now, where the birth of a son deprives the father of his public functions. In Metelin, a modification of the usage alluded to has been recently effected by the intervention of the Patriarch of Constantinople, together with the bishops and clergy of the island. Certain rights of primogeniture are preserved, by which the eldest daughter receives a third of the inheritance, the second a third of what remains, and the younger successively a third of the residue. Thus the immediate younger daughter, whatever be the number of the family, always receives a third of the remainder, after those before her have drawn their proportion.

The principal town, which is called Metelin or Castro, is situated on the east coast, where two harbours are formed by a mole of ancient construction. It is protected by a castle about three quarters of a mile in compass, consisting of two divisions of lofty embattled walls, each having its own governor and garrison, and these fortifications are defended by five or six hundred janizaries, most of whom are domesticated there. The population of the town amounts to two or three thousand Turks, three or four thousand Greeks, and thirty or forty Jewish families. It is a Bishop's See. Metelin covers part of the ground occupied by the ancient city. Molivo stands on the north coast, on the site of the ancient Methymnee, extending up the side of a hill, crowned by a spacious castle. It is about a mile in circuit, and contains about two or three thousand Turkish and Greek inhabitants; the latter have three churches and a bishop. The natives of this place are said to be distinguished as of old by a taste for music. Besides these, which are the principal places of the island, there are several villages, such as Petra, Akerona, Eresso, chiefly of small extent. Petra, or Porto Petra, on the west coast, is so named, from a high rock in the centre, which is accessible only from the north, and is surrounded on the top by a wall, whither the most valuable property is deposited by the inhabitants when alarmed for the depredations of Corsairs. At Akerona, on the north of Port Caloni, there is a desolate monastery, dedicated to St. John the Baptist. Eresso stands a little to the south of Cape Sigri in the neighbourhood of Ruins, denoting the situation of the ancient city of the same name. The houses in Metelin are constructed after a peculiar fashion, consisting of a square tower of hewn stone, raised so high as to overtop the trees, and command a view of the sea and the neighbouring island. The lower story is reserved for stores and granaries; and at the top are the apartments for the family, which are gained by a stair, chiefly built on the outside, and surrounding the tower.

Many celebrated men owe their birth to this island, among whom, perhaps, Theophrastus was the most distinguished, from having been a disciple of Plato, from Aristotle designing him for his successor, and also for the incredible number of his works. Pittacus, esteemed by the Greeks as one of their sages, was born in Lesbos, as also Alcæus and Sappho. In modern times, the two brothers named Barbarossa, the sons of a potter, who successively attained the rank of Dey of Algiers about the middle of the sixteenth century, owe their birth to this island.

Lesbos was one of the most famous islands of antiquity, but almost the whole remains of its grandeur are totally obliterated. Nothing but the faintest traces can be discovered of some of the eight cities which

Ptolemy says it contained. Four or five miles north-west of the town of Metelin are the ruins of a fine aqueduct, which has consisted originally of two arcades of grey marble surmounted by a kind of brick. In other places are seen the foundations of ancient castles and subterraneous cisterns. A white marble chair, of the age of Tiberius, which long attracted the notice of travellers, we have understood, has been lately acquired by a Scottish nobleman distinguished by his taste for Grecian antiquities.

Metelin has often changed its name. According to Diodorus it was called Issa; and after being occupied by seven generations of men, it was submerged by a flood, separating it from the continent, and destroying the whole inhabitants. Having regained sufficient fertility after subsidence of the waters, it was repeopled at a period which some conjecture to have been 1734, and others 1540 years anterior to the Christian æra. This island was often the theatre of warlike contentions during the subsistence of the Grecian States, and the influence of other nations in the Mediterranean. Under the name of Lesbos it became tributary to the Athenians, and afterwards formed part of the Roman Empire. It is uncertain when this appellation was changed; but Eustathius, who flourished in the twelfth century, mentions that it had been lately called Mytelene, as it was anciently denominated Lesbos. The Emperor John Paleologus ceded it to Gatilusio, a Venetian nobleman, under whose family it remained until besieged by Mahomet, who met with a determined resistance from the inhabitants. But their commander treacherously opened the gates of the town to the enemy in 1462, on a promise of being rewarded with the sovereignty of the Island. However, Mahomet, equally treacherous, put him to death when his services proved no longer useful. See Diodorus Siculus, *lib. iv.* § 81. Dallaway's *Constantinople, Ancient and Modern, p.* 312. Pococke's *Travels, vol. ii. part* 2. *p.* 15. *Transactions of the Royal Irish Academy, vol iii.* Guy's *Voyage Litteraire, tom. i. p.* 398 (*c.*)

METELLUS. See JUGURTHA and ROME.

METEOR. See METEOROLOGY.

METEORIC STONE. }
METEOROLITE. } See METEORITE.

METEORITE.

THIS term, derived from the Greek Μετεωρα, is here preferably adopted, as the shortest and most convenient appellation of a stony or metallic substance, which falls from the air, and whose descent is, generally, preceded or accompanied by a fiery meteor.

That stony, and even metalline bodies, have repeatedly impinged upon the earth's surface, and from great elevations, is a physical position from which no considerate and candid logician can any longer withhold his assent. The object of the ensuing pages, therefore, is not so much to prove the reality of such a phenomenon, as to supply our readers with a summary, but continuous review of its history, or, in other words, with a transcript of its modifications, and of the leading observations and reasonings to which it has given rise, thus approximating the results of various and dispersed documents, and reducing within a desirable compass the groundwork of future inquiry and discussion. We may, at the same time, confidently venture to indulge the reasonable expectation, that our exposition of facts and observations will suffice to convince those who have not heretofore examined the nature of the evidence on which it rests, that the phenomenon in question is neither doubtful nor chimerical, but entitled to all the credibility which can attach to human testimony.

In our present state of knowledge, we can feel no hesitation in ascribing a meteoric origin to certain detached masses of native iron, not merely because tradition accords with our opinion, but principally because the circumstance of their fall has been, in one instance at least, duly authenticated, and because their chemical constitution is, in some important particulars, analogous to that of undoubted meteorites. According to the discoveries of Proust and Klaproth, for example, native iron, reputed meteoric, differs from that which occurs in a fossil state, by the presence of nickel. Of the two pieces of Siberian iron in the Grevillian collection, one exhibits a cellular and ramified texture, analogous to that of some very light and porous volcanic slags. An attentive examination, moreover, reveals impressions or cavities of greater or less depth, and in some of which there remains a transparent substance, of a yellowish-green hue. The iron itself is very malleable, and may be cut with a knife, or flattened under the hammer. The other specimen is more solid and compact, but so blended and incorporated with the yellowish-green matter, that if the whole of the latter were subtracted, the remainder would consist of iron in the metallic state, and would present the same cellular appearance as the preceding. The stony portions of the composition usually assume the form of small nodules, generally of an irregular outline, but sometimes nearly globular, with a smooth, shining, and vitreous surface, and, both in aspect and properties, approaching to olivine. "I cannot help observing," says the Count de Bournon, "that there appears to exist a very interesting analogy between these transparent nodules and the globules I described as making part of the stones said to have fallen on the earth." The native iron from Bohemia, like the larger specimen from Siberia, is compact, and contains nodules, but not so numerous. They are, besides, quite opaque, and very much resemble the globules in atmospheric stones. This iron contains nearly 5 *per cent.* of nickel; and between 5 and 6 *per cent.* of the same metal seems to exist in a piece of native iron, brought from Senegal.

In like manner, we shall offer no apology for including in our chronological recital the mention of pulverulent or coloured showers, since the products of some of them seem to indicate a similar origin, and since, in several instances, their fall has even accompanied that of concrete masses. The colouring matter of alleged showers, however, has sometimes been found to be of a vegetable or animal nature, so that cases of this description are to be admitted with caution. Thus, the crimson snow, described by Captain Ross, in his account of his recent voyage to Baffin's Bay, is supposed by Dr. Wollaston to owe its complexion to some vegetable production, and Mr. Bauer fancies that he has detected in it the existence of a non-descript *Uredo*, which he, very appropriately, designates *nivalis*. With the exception of such instances, however, the black and reddish dusts, to which we shall have occasion to refer, may, perhaps, be regarded as replacing the grey and earthly portions of the friable meteoric stones. Nor is it improbable that the vitreous matter which accompanies the masses of native iron, may be the same portions completely fused, and that the dusts, meteorites, and ferruginous masses may have undergone different degrees of heat, which would account for their different modifications and appearances. Certain it is, that even sand was mingled in the Siena shower of stones, thus pointing to an intimate connection between silex in the loose and in the consolidated state, and thus justifying our insertion of the few examples of atmospheric sand that have come within our knowledge.

It may, moreover, be proper to premise, that although we have adopted Dr. Chladni's revised catalogue of meteoric appearances, and an article inserted in the second number of the Edinburgh Philosophical Journal, as the basis of our historical recapitulation of recorded cases, we by no means wish it to be understood, that we vouch for the truth of them all indiscriminately; for some of them rest on very slender or doubtful evidence; and a few we have purposely discarded, because we have been apprised, on unquestionable authority, that they were apocryphal. We may, however, pretty fairly presume, that the number of genuine occurrences of the phenomenon is, at least, not inferior to that which we purpose to quote; for it is reasonable to infer, that while the learned continued incredulous, even true reports might be rejected as fabulous; and several foreign collections of fossils contain specimens of reputed atmospheric origin, and exhibiting the features of meteoric physiognomy. It is, likewise, worthy of remark, that many fragments of *heavenly descent* may, at this moment, lie scattered on the earth, because, if abandoned but for a short time to the variations of humidity and temperature, to which the surface of our planet is constantly exposed, their metallic portions would be as speedily oxidized and degraded as a bit of polished steel, and thus render them to the eye of casual observation undistinguishable from morsels of those ferruginous stones which may be met with in almost every region of the globe. Besides, many relations of the phenomenon may have sunk into oblivion from the waste of time, or the stroke of calamity; and, on a fair computation of chances, meteors may have frequently exploded over desert tracts of land, or the pathless expanse of the waters.

From the sacred Scriptures of the Old Testament, we are not aware that any passage can be cited in direct proof of the descent of stones from the atmosphere. The ingenious but fanciful *Mr. Edward King*, indeed, in his "Remarks concerning stones said to have fallen from the clouds, both in these days and in ancient times," points to two passages as announcing such an event. The first occurs in the 13th verse of the 18th Psalm—*The Lord also thundered out of heaven, and the Highest gave his thunder: hail-stones and* COALS OF FIRE. This last expression has, no doubt, been conjectured to denote real hard bodies in a state of ignition: and the term *ανθρακες*, employed by the cautious Seventy, rather favours such an interpretation. The same expression, however, occurs in the verse immediately preceding, without admitting of this signification; and the phrase seems to be only a figurative mode of painting lightning; for, even in the sedate latitudes of the north, and in plain colloquial discourse, we currently talk of *balls of fire*, and *thunderbolts*, without any reference to solid matter. The other passage adduced by Mr. King, is the 11th verse of the 10th chapter of Joshua. *And it came to pass, as they fled from before Israel, and were in the going down to Beth-horon, that the Lord cast down* GREAT STONES *from heaven upon them unto Azekah, and they died: they were more which died with hail-stones than they whom the children of Israel slew with the sword.* Here the expression *great stones* is, perhaps, less ambiguous than *coals of fire*; yet the context hardly permits us to doubt, that these great stones were really hail-stones, or rather, perhaps, lumps of ice, formed in the atmosphere, such as occasionally fall in summer, and such as alarmed the whole of Paris and its neighbourhood, in July, 1788. At all events, the slaughter of the Canaanites is represented as resulting from the special interposition of divine power; and the consideration of miracles is irrelevant to our present purpose. In the New Testament, however, we find a passage, which may, perhaps, be construed as alluding, at least incidentally, to the traditionary fall of a meteorite; for, in the *Acts of the Apostles*, the chief magistrate of Ephesus is represented as thus addressing the people: *Ye men of Ephesus, what man is there that knoweth not how that the city of the Ephesians is a worshipper of the great goddess Diana, and of the image* WHICH FELL DOWN FROM JUPITER? or, more literally, OF THAT WHICH FELL DOWN FROM JUPITER. According to some learned commentators, this image was merely a conical or pyramidal stone, which fell from the clouds; and it appears that various other images of the heathen deities were nothing else. Thus, *Herodian* expressly declares, that the Phenicians had no statue of the sun, polished by the hand, but only a certain large stone, circular below, and terminated acutely above, in the figure of a cone, of a black colour, and that they report it to have fallen from the heavens. Nor is it at all surprising that rude and superstitious tribes should attach ideas of veneration and mystery to a solid and ignited body, precipitated from the sky. But even the complete silence of the sacred volume with respect to any physical appearance, does not imply its non-existence during the periods to which that volume refers; for scientific statements form no essential part of the plan of revealed religion; and stony bodies may have occasionally descended from the sky, in the peopled or unpeopled regions of the globe, as comets and eclipses may have attracted the attention of mortals, though not indicated by the inspired penman.

If from sacred we turn to the early periods of profane history, we shall find the annals of public events very copiously interspersed with notices of prodigies and strange appearances, many of which we may safely ascribe to the ascendancy which superstition long maintained over the human mind, so that it becomes extremely difficult, after the lapse of many ages, and in the collation of records which savour of the marvellous, to separate truth from fiction. Thus, in regard to the topic before us, we are fully authorised to discard from our ex-terrestrial catalogue certain modifications of sulphuret of iron, belemnites, orthoceratites, &c. which the observations of intelligent naturalits have proved to be of mineral or animal formation, as also the heads of arrows and sharpened flints, which have been fashioned by the hand of man, though the vulgar may, in the earlier stages of society, have attributed to them a celestial origin, and ranked them among *thunder stones*: but, when substances differing from these, and coinciding in any one character or circumstance with modern specimens of meteorites, are affirmed by the ancients to have fallen from the clouds, the remoteness of the epochs, and the lameness of the documents, may considerably affect our appreciation of the reputed evidence. Hence, when we touch much more lightly on the ancient than on some of the more recent testimonies, we are far from maintaining the certainty even of the particular instances selected; but, as the indiscriminate scepticism of the learned is scarcely less reprehensible than the blind credulity of the barbarian, we reckon it fair to admit their probability, and the weight which the mention of them may be considered as adding to that of subsequent and more circumstantial narratives.

Chronological History of Meteorites, interspersed with Remarks.

A. C. 1478. The thunder-stone in Crete, mentioned by *Malchus*. *Par. Chron.*—1200. Stones preserved in Orchomenos. *Pausan.*—1168. A mass of iron, on Mount Ida, in Crete. *Par Chron.*—705, or 704. The *Sacred Shield*, or *Ancyle*, which fell in the reign of Numa, of nearly the same shape with the mass that fell at Agram. But, if it really was of *brass*, and fell into *Numa's hands*, as mentioned by *Plutarch*, we may well suspect a *pious fraud*. 654. During the reign of Tullus Hostilius, a shower of stones fell on Mount Alba, and, when the senate deputed commissioners to ascertain the fact, they were assured that stones had really fallen, as thick as hail impelled by the wind. Similar events, adds the eloquent *Livy*, were celebrated by a festival of nine days. At that period, then, the fall of stones was solemnly recognized as a supernatural occurrence: the nature of the masses, however, is not particularly described; and, on subsequent occasions, the same historian has usually recourse to the general expression, *lapidibus pluere*, without farther comment or explanation.—644. According to *De Guignes*, the early historians of China make mention of five stones having fallen from the heavens, in the district of Song. 520. A stone fell in Crete, in the time of Pythagoras. *Calmet.*—466. *Pliny*, in the 58th chapter of the second book of his Natural History, commemorates the descent, in the day-time, of a stony mass, as large as a cart, and of a burnt colour, near Egospotamos in Thrace, and affirms that it was still exhibited in his time. The *magnitudine vehis* of this author may probably mean, that it was of such dimensions, that it could be conveyed in a cart; and some commentators read *vehibilis*. The Greeks pretended that it had fallen from the sun, and that Anaxagoras had predicted the day of its arrival on the earth's surface. Such a prediction, the naturalist observes, would have been more marvellous than the stone; and all knowledge, he adds, must be confounded, if either we admit the sun to be a stone, or a stone to fall from that luminary to the earth. Yet, whatever may have been the ingenious or the absurd surmises of those days, the reputed event became a subject of such notoriety, that the author of the Athenian Chronicle, a document published by Selden, along with the Arundelian marbles, formally places it under the 58th epoch, and in the 113th year of the Attic or Cecropian era. That Anaxagoras foretold the day of the fall, may as well be doubted, as that Sir William Herschel should have lent himself to the occupation of Moore the Almanac-maker: but we learn from a passage in the first book of Silenus, preserved by Diogenes Laertius, that the incident which we are now considering, suggested to the philosopher of Clazomene the hypothesis which he delivered to his disciples, namely, that the sky was a solid vault, composed of large stones, which its rotatory motion kept at a due distance from the centre, to which they would, otherwise, inevitably tend. We may also remark, that Pliny broadly asserts the frequent occurrence of the phenomenon—*decidere tamen crebro, haud erit dubium.* Some curious notices relative to the Thracian stone have likewise been preserved by Plutarch, in his Life of Lysander. It fell, he remarks, at Egospotamos, was of enormous dimensions, and was exhibited as a public spectacle by the people of the Chersonesus, who held it in great veneration. His account of the meteor is principally borrowed from Damachus or Daimachus, whom Strabo represents as addicted to fiction, and ignorant of geometry.

"During seventy-five successive days," says the biographer, "previous to the fall of the stone, a large fiery body, like a cloud of flame, was observed in the heavens, not fixed to one point, but wandering about with a broken, irregular motion. In consequence of its violent agitation, several flaming fragments were forced from it, which were impelled in various directions, and darted with the velocity and splendour of so many falling stars. After this body had alighted in the Chersonesus, and the inhabitants, recovered from their alarm, had assembled to see it, they could perceive no inflammable matter, nor the slightest trace of fire, but a real stone, which, though large, was nothing when compared to the volume of that fire-ball which they had seen in the sky, but appeared only as a piece detached from it." "It is obvious," continues Plutarch, "that Damachus must have very indulgent readers, if this account of his gains credit. If it is a true one, it completely refutes those who allege that this stone was merely a rock, torn by a tempest from the top of a mountain, and which, after being conveyed for some time in the air, by means of a whirlwind, settled on the first spot where the violence of the latter abated. This phenomenon, which lasted for so many days, was, perhaps, after all, a real globe of fire, which, when it dispersed, and became nearly extinct, might induce such a change in the air, and generate such a whirlwind, as might tear the stone from its native bed, and dash it on the plain."

Damachus, it is true, may, on this occasion, have given way to his love of the marvellous; and we can readily believe, that the seventy-five continuous days are either an error of the copyist, or an original exaggeration. When we reflect, however, that he is not the sole reporter of the occurrence, and that some of the circumstances which he specifies are very analogous to those which remain to be stated on less questionable authority, we can hardly refuse to acquiese in the presumption, that a meteorite really fell at the period, and on the spot, which are here so particularly specified.

465. The stone denominated *the mother of the gods*,

alluded to by so many ancient writers, and the source of so many learned, and so many foolish conjectures, is stated by *Appian*, *Herodian*, and *Marcellinus*, *to have fallen from heaven.* *Aristodemus*, quoted by the Greek scholiast on Pindar, asserts, that it fell, *encircled by fire*, on a hill, and at the feet of the Theban bard. It is said to have been of moderate dimensions, of a black hue, of an irregular angular shape, and of a metallic aspect. An oracle had predicted, that the Romans would continue to increase in prosperity, if they were put in possession of this precious deposit; and Publius Scipio Nasica was accordingly deputed to Attalus, king of Pergamus, to obtain and receive the sacred idol, whose worship was instituted at Rome, 204 years before the Christian era. According to *Valerius Maximus*, a stone fell in the March of Ancona: Livy even says, *lapidibus pluit*, which would intimate a shower of them.—343. A shower of stones near Rome. *Jul. Obseq.* 211.—*De Guignes* relates, that a *star fell to the ground* in China, and was *converted into a stone*—an event which created an extraordinary sensation. The inhabitants of the district, willing to convey a moral lesson to their unpopular emperor, caused these words to be engraved on the stone: *Chi-Hoang-Ty draws near to death, and his empire will be divided.* In the plenitude of his indignation, the emperor ordered all the inhabitants of the district to be put to death, and the stone to be broken in pieces; but he died in the course of the following year; and, three years after, in the reign of his successor *Eul-Chi-Hoang-Ty*, in consequence of a general revolt, the empire was partitioned into many kingdoms, and the dynasty of the Tsins was extinguished.—205, or 206. A shower of fiery stones. *Plut.*—192. A stone fell in China. *De Guignes.*—176. A stone is reported by *Livy*, to have fallen into the Lake of Mars, in the Crustumenian territory.—90, or 89. A shower of stones like bricks. *Plin.*—89. Two large stones fell at Yong, in China; and the noise of the explosion was heard over forty leagues. *De Guignes.*—56, or 52. Spongy iron in Lucania. *Plin.*—A shower of stones at Acilla, a town in Africa, mentioned in *Cæsar's Commentaries.*—38. Six stones fell in the province of Leang in China, *De Guignes.*—29. Four at Po, and two in the territory of Tching-ting-fou. *Id.*—22. Eight in China, *Id.*—19. Three in China. *Id.*—12. One at Ton-Korean. *Id.*—9. Two in China. *Id.*—6. Sixteen in Ning-Tcheou, and two at You. *Id.* We may believe, on the authority of De Guignes, that such notices are inserted in the records of China; but we are too little conversant in the literature of that singular country, to determine the precise quantity of credence that ought to attach to the notices themselves; yet, had no such events ever occurred in that part of the world, it is not very probable that they would have been so repeatedly and distinctly registered.

P. C. A stone in the territory of the Vocontii, deposited a little before Pliny saw it.—Mondognetius, in his Life of Marcus Aurelius, relates, that, in the reign of the Emperor Valentinian, such a copious shower of stones fell at Constantinople, that it killed most of the cattle in the fields, and even some people.—452. Marcellinus, an officer of the empire, and Count of Illyria, who lived in the reign of Justinian, and continued the chronicle of Jerome, from A. D. 379, to 534, makes mention of three large stones which fell from the heavens in Thrace; but he is silent as to particulars.—Nov. 5, or 6, 472. A great fall of black dust, probably at Constantinople, during which the heavens seemed to burn.—*Procop. Marcell. Theoph.* &c. Sixth century. Stones fell on Mount Lebanon, and near Emessa in Syria. Damascius, in an extract of his Life of Isodorus, preserved by Photius, relates that the former issued from *a globe of fire.*—About 570, a shower of stones, near Bender, in Arabia. *Alcoran.*—648. A fiery stone at Constantinople, according to several chronicles.—652. A shower of red dust at the same place. *Theoph. Cedren. Math. Eretz.*—811. In the third moon, on the day Wou-siu, between the third and fifth hour after mid-day, the sky being cloudy, and the weather cold, there appeared a globe of fire as large as a *hou*, (a measure of about ten bushels.) which fell between *Yan* and *Yun.* A noise, resembling thunder, was heard at the distance of many leagues, and the people fled with a violent outcry. Above the place where the globe fell, a reddish vapour remained, arranged like a serpent, and a *tchang* (nearly 12½ feet) in length; it remained till the evening, and then disappeared. *Ma-touan-lin.*—817. In the twelfth year, in the ninth moon, on the day Ki-kaï, about the third or fourth hour after mid-night, there appeared a running star towards the middle of the heavens; its head was like a bucket, and its tail like a bark of 200 *hou* burthen; it was more than ten tchang in length, and made a noise like a number of birds flying; it produced a light similar to that of the torches used in illuminations. It passed beneath the moon, moving towards the west; on a sudden, a great noise was heard, and at the moment the globe fell to the earth, a crash took place thrice as great as that of a falling house. *Id.*—823. A shower of pebbles in Saxony. *Mezeray*, and *Bonaventure de St. Amable.*—839. It is recorded in the history of Japan, that, in the sixth year of Nin-mio-teno, the 29th day of the eighth moon, there occurred at a place to the west of the town of Thean-tchhenan, where no fragment of stone previously existed, thunder and rain for ten days. The weather having become clear, stones similar to the points of arrows and to hatchets, were found on the earth, some being white and others red.—July, or August, 852. A stone fell in Tabaristan. *De Sacy*, and *Quatremère.*—Middle of the ninth century. Red dust, and matter like coagulated blood, fell from the heavens. *Kaswini*, *Elmazen.*—December, 856. Five stones fell in Egypt. *De Sacy*, *Quatremère.*—885, 886, and 887. Thunder-stones fell in Japan. *Ma-touan-lin.*—892 or 897. A stone fell at Ahmedabad. *Quatremère.*—905. Stones fell at Hoanglie, in Corée, which caused a noise like thunder. The officers of the place having sent these stones to the court, the president of the ceremonies assured the king that the phenomenon of falling stars had occurred so frequently, that it was no longer regarded as a prodigy. In China, certain stones of a black or violet colour are called *thunder-hatchets*, *scissors*, *hammers*, &c. according to their forms; and although they may have been wantonly multiplied, some of them are, probably, of meteoric origin. *Ma-touan-lin*, who registers the occurrences of falling stones in China, supposes that these thunder-stones are identical with them.—929. A fall of red sand, from a red sky, at Bagdad. *Quatremère.*—951. A stone fell near Augsburg, (not in Italy.) *Albertus Stadius*, and others.—Between 956 and 972. Platina, in his Life of Pope John XIII. enumerates, among the prodigies of the times, the descent of a very large stone during a furious tempest of wind and rain.—998. Cosmas and Spangenberg relate, that two large stones fell with an explosion like thunder, one of them alighting in the town of Magdeburg, and the other in the open country near the Elbe. —1009. Avicenna affirms, that when in *Djordjan*, (misrepresented *Lurgea* and *Cordova*.) he saw a sulphureous kind of stone fall from the atmosphere.—Between the 24th of July and the 21st of August, 1021, stones fell in Africa. *De Sacy*—1056. Red snow fell in Armenia. *Math. Eretz.*—1110. A burning body fell into the Lake of Van, in Armenia, and made its waters blood red, while the earth was cleft in several places, probably with stones. *Id.*—1112. Stones or iron fell near Aquileia. *Valvasor.*—1135 or 1136 Spangenberg and others inform us, that a stone as large as the human head was precipitated from the air at Oldisleben in Thuringia.—1164 George Fabricius, in the First Book of the History of Misnia, apprizes us of a shower of iron in that country, at Whitsuntide —1198. Stones fell near Paris *Henri Sauval*—July 26, 1249. Spangenberg and Rivander again mark the descent of stones in the neighbourhood of Quedlinburg, Ballenstaedt, and Blankenburg, in Saxony.—Thirteenth century. A stone fell at Wurtzburg. *Schotti Phys Cur.*—Between 1251 and 1363, stones fell at Welixoi-Ussing, in Russia *Gilb An.* —1280 A stone fell at Alexandria, in Egypt. *De Sacy.* —Oct. 1, 1304, Krantz, in his Account of Saxony, and several of the German Chroniclers, concur in stating, that many stones fell near *Friedland* or *Viedeland*, and that they did grea damage to the fields. But the *Friedland* of these authors, who probably copied from one another, is not sufficiently particularized, as there are many small towns and villages of that name. Spangenberg more pointedly mentions *Friedberg*, near the Saale.—1305. Burning stones fell in the country of the Vandals. *Bonav. de St Amable.*—Jan. 9, 1328. Stones fell in Mortahia and Dakhalia. *Quatremère.*—1360. Several stones were observed to fall from the clouds in Yorkshire. *Phil. Mag.*—1368 A mass of iron fell in the Duchy of Oldenburg. *Siebrand, Meyer.*—May 26, 1379. Stones fell at Minden, in Hanover. *Lerbecius.*—1416. Red rain in Bohemia. *Spangenberg.*

1438. According to Proust, the chemist, stones of a spongy texture were observed to fall near Roa, at no great distance from Burgos, in Spain; and, in support of his assertion, he quotes the ensuing extract of a letter from the Bachelor Cibdaréal.

"King Don Juan and his court being engaged in a hunting party, under the village of Roa, the sun was obscured by white clouds, and they saw descending from the air bodies which resembled grey and blackish stones, and of such considerable dimensions as to excite the greatest astonishment.

"This phenomenon continued during an hour, after which the sun reappeared, and the falconers, mounted on their horses, immediately repaired to the spot, which was not half a league distant. They reported to the king, that the field on which these stones lay, was so thickly strewed with them, of all sizes, as completely to conceal the soil.

"The king was desirous of visiting the scene, but his courtiers restrained him, by representing, that the place which heaven had selected for the theatre of its operations might be unsafe, and that it would be more advisable to detach one of his suite. Gomes Bravo, Captain of his Guards, volunteered his services, and brought with him four of these stones to Roa, whither the king had now retired. They were of a considerable size, some round, and as big as a mortar, others shaped like pillows or half fanego measures: but the circumstance which created most astonishment, was their extreme levity, for the largest did not weigh half a pound. They were of such a delicate texture, that they resembled sea-froth condensed more than any thing ese. You might strike your hand against them, without any apprehension of contusion, pain, or the least mark."

In respect of specific gravity, these stones must have differed very materially from the heavier specimens of recent date. From the fragility of their texture, no trace of their existence probably now remains; but the narrative, which bears all the marks of a genuine document, may be regarded as, in some measure, corroborative of the fall of the *spongy* masses, noticed by Pliny, and of the *fleecy* showers of that naturalist. In the present instance, too, no mention is made of any luminous appearance or explosion, and it is not even said that the masses felt hot when first touched.

Some time in the same century, a stone, and a mass like coagulated blood, accompanied by a *fiery dragon*, (meteor), fell near Lucerne. *Cysat.*—1480. Stones fell in Saxony and Bohemia. *Philos Mag.*—1491. A stone fell near Crema. *Simonetta.*

November 7, 1492.—The far-famed stone of Ensisheim has exercised the talents of contemporaneous writers, both in prose and verse. Professor Batenschoen, of the central school of Colmar, first directed the attention of naturalists to some of the old chronicles, which record the circumstances of its fall with much simplicity, and in the true spirit of the times The note which accompanied the stone, when it was suspended in the church of Ensisheim, may be rendered thus:

"In the year of the Lord 1492, on Wednesday, which was Martinmas eve, the 7th of November, there happened a singular miracle; for, between 11 o'clock and noon, there was a loud peal of thunder, and a prolonged confused noise, which was heard to a great distance, and there fell from the air, in the jurisdiction of Ensisheim, a stone which weighed 260 pounds, and the confused noise was, moreover, much louder than here. Then a child saw it strike on a field, situated in the upper jurisdiction, towards the Rhine and Inn, near the district of Gisgand, which was sown with wheat, and did it no harm, except that it made a hole there, and then they conveyed it from that spot, and many pieces were broken from it, which the Landvogt forbade. They, therefore, caused it to be placed in the church, with the intention of suspending it, as a miracle; and there came here many people to see this stone. So there were remarkable conversations about this stone, but the learned said that they knew not what it was, for it was beyond the ordinary course of nature that such a large stone should smite the earth to the depth of a man's stature, which every body explained to be the will of God that it should be found, and the noise of it was heard at Lucerne, at Villing, and in many other places, so loud, that it was believed houses had been overturned; and, as the King Maximilian was here the Monday after St. Catharine's day of the same year, his Royal Excellency ordered the stone which had fallen to be brought to the castle, and, after having conversed a long time about it with the noblemen, he said that the people of Ensisheim should take it, and order it to be hung up in the church, and not to allow any body to take any thing from it. However, his Excellency took two pieces from it, of which he kept one, and sent the other to the Duke Sigismond of Austria, and they spoke a great deal about that stone, which they suspended in the choir, where it still is; and a great many people came to see it." According to *Trithemius*, it fell with so much violence that it broke into two pieces, of which only the most considerable was suspended in the church. *Paul Lang* describes its form as corresponding to that of the Greek Delta, with a triangular point. Both of these writers lived at the period which they assign to the descent of this remarkable mass; and, although their names are fast hastening to obscurity, it behoves us to observe, that Trithemius yielded to few of his contemporaries in labour and learning, and that Lang, though a Benedictine monk, travelled in quest of historical monuments, and had the candour and boldness to arraign the license of the Roman Catholic clergy, while he applauded the independence of Luther and Melancthon. We may add, that Maximilian, who, shortly after this period, was elevated to the imperial dignity, in a Rescript dated Augsburg, November, 12, 1503, expressly refers to the stone in question, as having fallen in an open field before him, when he commanded the army which he had levied against the French; and that, availing himself of the apparently miraculous event, he exhorted the Germans to a new crusade against the Turks.

During the French Revolution, this large meteorite was found still suspended in the church, but it weighed only 171 lb. The French removed it to the National Library at Colmar, and, notwithstanding the many fragments which have been detached from it, the mass still weighs 150 lb A large specimen is preserved in the Cabinet of the Parisian Museum, another in the Imperial Cabinet at Vienna, and we have seen another small fragment in the valuable and interesting collection of Robert Ferguson of Raith, Esq.

The Ensisheim stone is of a schistose texture, of a slate-grey colour, and composed of small shining particles of granular portions of a whitish-grey, blended with thin laminæ of a slate-grey fissile substance of grains or globules of pure iron, and of grey and shining sulphuret of iron and nickel. The cross fracture is very unequal, and the longitudinal waving, in the direction of the laminæ, and, at the same time, tough and harsh. Such parts of the outer surface as remain entire are coated with a blackish vitrified crust. It gives no argillaceous odour by insufflation; and, under the blowpipe, the grey portions become black, and are converted into frit Its specific gravity is 3 23, and its analysis yielded to Vauquelin,

Silica	56.
Lime	1.4.
Magnesia	12.
Oxide of iron	30.
Nickel	2 4
Sulphur	3.5
	105.3

Its principal peculiarity, therefore, is its schistose texture.

January 28, 1496. Marcus Antonius Sabellicus, in the second volume of the Lyons edition of his works, (p. 341,) mentions the fall of three stones between Cesena and Bertonosi. Bonfinius, or rather, we presume, his continuator, reports, that a shower of stones fell near the village of Munkbergen in the course of the same year, and that the inhabitants amused their fancy by tracing on the fallen fragments outlines of the human countenance and diadems.—1501. According to different chronicles, showers of blood fell in several places.—1510. In the Commentary of Surius, a Carthusian monk of Cologne, mention is made of a shower of large stones in Lombardy, they are described, probably with some exaggeration, as harder than flint, smelling of Sulphur, &c. But the same event is more particularly commemorated by Cardan in his Treatise *De Rerum Varietate*; for he informs us, that between Cremasco or Crema, and Milan, and not far from the river Adda, at five o'clock in the evening, about twelve hundred stones fell from the air, one of which weighed 120 lb. and another 60 lb. Many were presented as curiosities to the French Governor and his Deputy. At three o'clock in the afternoon, the sky appeared as if in a general blaze, and the passage, though somewhat ambiguous, would lead us to infer, that the fiery meteor was visible for two hours. Like many of the learned and unlearned of his day, Cardan immediately connects the extraordinary appearance with the political transactions of his petty district. The same incident is noticed by Leonardus in his *Mirror of Stones*, and by Bondini in his *Theatrum Naturæ*. The following passage is extracted from a series of *Observations on Natural History, Meteorology*, &c. made in the early part of the 16th century, by Andrea da Prato of Milan, which, though not published, have been repeatedly copied in MS. It seems to allude to the same occurrence, although the year quoted is 1511.

"On the fourth of September, at the second hour of the night, and also at the seventh, there appeared in the air, at Milan, a running fire, with such splendour, that the day seemed to have returned, and some persons beheld the appearance of a large head, which caused great wonder and fear in the city. The same thing happened on the following night at the ninth hour. A few days after, beyond the river Adda, there fell from Heaven many stones, which, being collected at Cremasco, were found to weigh 8 lb and even 11 lb. each. Their colour was similar to that of burned stones." Dr Bossi, in commenting on this statement, endeavours to account for the space of time which appears to have intervened between the meteor and the fall of stones, by supposing it occupied in conveying the intelligence from Crema to Milan.

1516 In the year Wan-li, of the dynasty of Ming, in the 12th moon, on the 25th day, at Chun-khing-fou in the province of Soe-tchhouan, there was neither wind nor clouds, when the thunder rumbled suddenly, and six globular stones fell, of which one weighed eight pounds another fifteen, a third twenty-seven, the smaller not more than a pound, and the smallest of all only ten ounces *Ma-touan-lin*.—May, 1520, stones fell in Arragon *Diego de Sayas*.—April 28, 1540, a stone fell in the Limousin. *Bonav. de St. Amable*.—Between 1510 and 1550, Albinus in his Chronicle of Misnia, records the fall of a large ferruginous mass, in a forest near *Neuhof* between Leipsic and Grimma, in Saxony; but Jonston and Alberti write *Neuholem* others, *Naunhoff-Na* &c. A specimen of this mass is still to be seen in the imperial cabinet in Vienna. Some time about the same period, iron fell in Piedmont *Mercati* and *Scaliger*.—November 6, 1548. According to Spangenberg and Bonaventure de St. Amable, a blackish mass, accompanied with a red substance, like coagulated blood, and with a loud noise, fell at Mansfeldt in Thuringia.—May 19, 1552. From the same source we learn, that a shower of stones made great havoc in the environs of Schleusingen, also in Thuringia. That this was not a hail shower is obvious, from the circumstance that Spangenberg carried several of the stones with him to Eisleben.—1559. It is related in the 16th vol. of the *Breslaw Collection*, and in Isthuanfius's History of Hungary that five stones, said to be preserved in the treasury of Vienna, each of the size of a man's head, exceedingly heavy, of a rusty-iron colour, and emitting a strong smell of sulphur, fell from the heavens, with explosions and a dreadful concussion of the air, at Miscoz, in Transylvania.—Whitsuntide, 1560. Red rain at Embden, Louvain, &c. *Fromond.*—December 24 1560. A fiery meteor, and red rain at Lillebonne. *Natalis Comes.*—May 17, 1561. A stone fell at Eilenborg, in the Torgau. *Gesner* and *de Boot.*—May 27, 1580 Stones fell near Göttingen. *Bange.*—July 26, 1581. Between one and two o'clock in the afternoon, a stone, weighing 39 lb. of a blue and brownish colour, and which gave fire with steel, fell from the air, in Thuringia, with an explosion which shook the earth, and accompanied by the appearance of a small light, which was supposed to be a fire-ball, the heavens being, in other respects, serene. It sunk into the soil to the depth of a yard and a quarter, tossed up the earth to twice the height of a man; and was at first so hot that nobody could touch it. After some time had elapsed, it was carried to Dresden. Binhard's *Chronicle of Thuringia*, *Olearius.*—January 9, 1583, stones fell at Castrovillari. *Casto*, *Mercati*, and *Imperati.*—Ides of January, 1583. Mercati mentions, that some of the inhabitants of Rosa, in Lavadie, who were walking on the neighbouring heights, in serene weather, observed a thick black cloud, which exploded near them with such violence, that they fell almost senseless to the ground, and that, on recovering from their alarm, they immediately repaired to the spot, and found a stone of about 30 lb., which resembled iron —March 2, 1583. A stone, of the size of a hand grenade, fell in Piedmont.—1585. A stone fell in Italy. *Imperati.*—December 3, 1586. A great quantity of red and blackish matter, which burned some planks, and was accompanied by thunder and lightning, fell at Verden, in Hanover. *Solomon*, Senator of Bremen. —June 9, 1591. Angelus, in the *Annales Marchiæ*, and *Lucas* affirm, that some large stones fell at Kunersdorf. —1591. A shower of blood at La Magdelaine, near Orleans. *Leman*, in *Nouv. Dict. d'Hist. Naturelle.* —March 1, 1596, stones fell at Crevalcore, Mittarelli. Some time in the course of the sixteenth century, and not, as alleged, in 1603, a stone, exhibting metallic veins, is reported to have descended in the province of Valencia, in Spain. *Cæsius*, and the *Jesuits of Coimbra*, in their remarks on Aristotle's Meteorology —August, 1618, a great fall of stones, with a shower of blood, occurred in Styria. *De Hammer.*—1618. A metallic mass fell in Bohemia. *Kronland.*

April 17, 1620, the Emperor, Jehangire, in his Memoirs written by himself, in the Persian language, and translated by Colonel Kirkpatrick, from an old MS. thus relates the fall of a piece of meteoric iron.

"A. H 1030, or 16th *year of the reign.*—The following is among the extraordinary occurrences of this period.

"Early on the 30th of Furverdeen, of the present year,* and in the Eastern quarter (of the heavens,) there arose in one of the villages of the Purgunnah of Jalindher,† such a great and tremendous noise, as had nearly, by its dreadful nature, deprived the inhabitants of the place of their senses. During this noise, a luminous body (was observed) to fall from above on the earth, suggesting to the beholders the idea that the firmament was raining fire. In a short time, the noise having subsided, and the inhabitants having recovered from their alarm, a courier was dispatched (by them) to Mahommed Syeed, the Aumil‡ of the aforesaid Purgunnah, to advertise him of this event. The Aumil, instantly mounting (his horse,) proceeded to the spot (where the luminous body had fallen) Here he perceived the earth, to the extent of ten or twelve guz,§ in length and breadth, to be burnt to such a degree, that not the least trace of verdure, or blade of grass remained ; nor had the heat (which had been communicated to it) yet subsided entirely.

"Mahommed Syeed hereupon directed the aforesaid space of ground to be dug up ; when, the deeper it was dug, the greater was the heat of it found to be. At length, a lump of iron made its appearance, the heat of which was so violent, that one might have supposed it to have been taken from a furnace. After some time it became cold, when the Aumil conveyed it to his own habitation, from whence he afterwards dispatched it, in a sealed bag, to court.

"Here I had (this substance) weighed in my presence. Its weight was one hundred and sixty tolahs.‖ I committed it to a skilful artisan, with orders to make of it a sabre, a knife, and a dagger. The workman (soon) reported, that the substance was *not malleable, but shivered into pieces under the hammer.*¶

"Upon this, I ordered it to be mixed with other iron. Conformably to my orders, three parts of the *iron of lightning*** were mixed with one part of common iron ; and from the mixture were made two sabres, one knife, and one dagger.

"By the addition of the common iron, the (new) substance acquired a (fine) temper; the blade (fabricated from it) proving as elastic as the most genuine blades of Ulmanny,†† and of the South, and bending, like them, without leaving any mark of the bend. I had them tried in my presence, and found them cut excellently ; as well (indeed) as the best genuine sabres. One of these sabres I named *Katai*, or the *cutter ;* and the other *Burk-serisht*, or *the lightning natured.*

* "The first of Furverdeen of this year, (A. H. 1030,) corresponded with Saturday the 27th of Rubbi ul Akhir; consequently, the 30th of Furverdeen fell on the 26th of Jumad ul Oruvul, or, A. D. 1620"

† "A purgunnah is a territorial division, of arbitrary extent. The purgunnah of Jalindher is situated in the Punjaub, and about 100 miles S. E. of Lahore."

‡ "Aumil is a manager, or fiscal superintendant of a district."

§ "A guz is rather less than a yard."

‖ "A tolah is about 180 grains, Troy weight."

¶ "Literally, it did not stand beneath the hammer, but fell to pieces."

** "This expression is equivalent to our term *thunderbolt.*"

†† "The name of the place here designed, is doubtful."

" A poet* composed and presented to me, on this occasion, the following tetrastich.

" This earth has attained order and regularity through the Emperor Jehangire :

" In his time fell *raw* iron from lightning :

" That iron was, by his world-subduing authority,

" Converted into a dagger a knife, and two sabres."

But, what is more to our purpose, the late Hon. Charles Greville, at whose request Colonel Kirkpatrick translated the foregoing quotation, has remarked, that the Emperor Jehangire was not a prince on whom his courtiers would idly venture to impose; and that there can be little probability that an Aumil of a district should invent such a story, or be able to produce a substance like iron, but which, on trial, should differ from manufactured iron.

January 10, 1622, a stone fell in Devonshire. *Rumph.* —April 9, 1628, stones fell near Hatford, in Berkshire. *Gent Mag.*—December 6, 1631. The following letter from Captain William Badily, is inserted in the first volume of the Philosophical Transactions. " The 6th of December, 1631, being in the Gulf of Volo, riding at anchor, about ten of the clock that night, it began to rain sand or ashes, and continued till two of the clock next morning. It was about two inches thick on the deck, so that we cast it overboard with shovels, as we did snow the day before : the quantity of a bushel we brought home, and presented to several friends,† especially to the Masters of Trinity House. There was in our company, Captain John Wilds, Commander of the Dragon, and Captain Anthony Watts, Commander of the Elizabeth and Dorcas There was no wind stirring when these ashes fell ; it did not fall only in the places where we were, but likewise in other parts, as ships were coming from St. John d'Acre to our port : they being at that time a hundred leagues from us. We compared the ashes together, and found them both one."

October 27, 1634, stones fell in the Charollois. *Morinus.*—June 21, 1635. *Francesco Carli*, a learned, and highly respectable gentleman of Verona, reports the fall of a large stone at five o'clock in the evening. It was preceded by a great mass of flame, which traversed the Lago di Garda with such velocity, that the eye could scarcely follow its motions, illuminated all the country in the path of its passage, shaking the houses with its loud explosion, and alighting on the grounds of the Benedictine monks, under the town of Vago, about six Italian miles from Verona. Next morning there was found, on the spot on which it had alighted, a stone, invested with a black and channelled crust, which had penetrated about a yard into the soil, and was broken into several pieces, the largest of which was of a cubical form, of nearly a yard and a half on every side, of the colour of ashes, giving out an offensive odour of sulphur, and having minute particles of iron disseminated through its substance.

Saturday, July 7, 1635. During a violent storm, a stone, weighing about 11 oz fell at Calce. in the Vicentine territory. *Valisnieri*—March 6, 1636. During a perfectly serene sky, a large stone fell, with a loud crash, between Sagan and the village of Dubrow, in Silesia. It was covered with a crust, had, internally, the appearance of a metallic slag, and seemed as if it had been acted on by fire. *Lucas. Seschiche's Chron. Cluver. Geogr.*—1638. Red rain at Tourney.—November 29, 1639, (not 1629, nor 1627, as mis-quoted by some writers) In the third Section of the Second Book of his Physics, the celebrated Gassendi, whose accuracy and veracity will not be readily impeached, states, that, at ten o'clock in the morning, a stony mass, regarded as a thunder-stone, was seen by three creditable witnesses, to fall on Mount Vaision, one of the Maritime Alps, when the ground was covered with snow, and the sky perfectly serene. The spot is indicated as lying between the small towns of Guillaumes and Perne, in Provence. Many, for a great way round, heard the explosion, but only three individuals saw the fire-ball. The noise which preceded it, they compared to the repeated discharge of artillery ; but two of the concussions were particularly tremendous ; and the reverberation of the last was immediately followed by a rumbling noise, like the beating of four or five drums, when a flaming circle, of varied hues and apparently of four feet in diameter, passed before the eyes of the spectators, accompanied with a loud hissing, like that of fire-works, and with a strong sulphureous odour. So far as could be conjectured, it had rushed on their view when at the distance of only a hundred paces from their persons; and they saw it strike the ground, like a black-bird with white spots, and smoke issue from the place where it fell, which was not beyond thirty paces from their own station. The noise which ensued on its striking the ground, was compared to the firing of musketry. The inhabitants of both towns flocked to the smoking scene, and found a hollow of nearly one foot wide, and three in depth, the snow being melted for five feet round, and the earth and small stones obviously calcined. In the bottom of the hollow was found the stone, about the size of a calf's head, but rounder and more approaching, in form, to that of a man. It was of a dark metallic colour, extremely hard, and weighed 54 Provençal, or 38 Parisian pounds, its specific gravity being to that of common marble, as 14 to 11.

Mons. Izarn, not only mis-dates the year and day of this appearance, but asserts that Gassendi himself saw it; whereas that philosopher expressly says, *ipse cum abessem.*

August 4, 1642, a stone, weighing 4 lb. fell between Woodbridge and Aldborough, in Suffolk *Gent. Mag* —1643, or 1644. Stones fell in the sea. *Wurfhain.*—Jan. 23, or 24, 1645. Red rain fell at Bois-le Duc.—Oct. 6, 1646 Red rain at Brussels *Kronland, Wendelinus* — Feb. 18, 1647. A stone fell near Zwickau. *Schmid* — August, 1647. Stones fell in the bailliage of Stolzenau, in Westphalia. *Gilb. An*—Between 1647 and 1654, a stone fell into the sea. *Willmann, Malte-Brun.*—August 6, 1650. We find it mentioned in Senguerd's *Physical Exercitations*, that a stone fell at Dordrecht.—March 30, 1654 Thomas Bartholinus adverts to a shower of stones, in the island of Funen, in Denmark. A large stone fell at Warsaw. *Pet Borellus* A small stone fell at Milan, and killed a Franciscan monk. *Museum Septalianum.*—June 19, or 21, 1668. A great fall of stones near Verona. *Valisnieri, Montenari*, and *Carli* From a book which was printed at Paris, in 1672, and which

* " The poet is named in the original ; but the name is not perfectly legible."
† Some of the ashes were produced by Mr. John Evelyn, before the Royal Society.

has now become very scarce, entitled, *Conversations tirées de l'Académie de Mons l'Abbé Bourdelot, contenant diverses recherches et observations physiques*, par le Sieur Legallois, we make the ensuing extract:

"One of the members presents a fragment of two stones which fell near Verona, one of which weighed 800 pounds, and the other 200 pounds. These stones," he says, "fell during the night, when the weather was quite mild and settled. They seemed to be all on fire, and came from above, but in a slanting direction, and with a tremendous noise. This prodigy terribly alarmed three or four hundred eye-witnesses, who were puzzled what to think of it. These stones fell with such rapidity that they formed a ditch, which, after the noise and flame had ceased, the spectators ventured to approach, and examine them more nearly. They then sent them to Verona, where they were deposited under care of the Academy; and that learned body sent fragments of them to different places. This account induced the Society to consider the fragment in question with particular attention; and they remarked that it was of a yellowish colour, very easily reducible to powder, and that it smelled of sulphur." In the course of examining one of these stones, M. Laugier, professor of pharmacy at Paris, detected in it, by means of the caustic alkali, the presence of chrome.

February 27, 1671 Stones fell in Swabia. *Gilb. An.*—1673. Some stones fell in the fields near Dietling, and were deposited in the museum of Brackenhofer. *Leonardus de Gemmis*, and *Memorie della Societa Colombaria Fiorentina*.—October 6, 1674, Scheuzer affixes this date to the descent of two large stones in the canton of Glarus.—Between 1675 and 1677, a stone fell into a fishing boat near Copinsha, in the Orkneys. Wallace's *Account of Orkney*, *Gent. Mag* "The air and clouds here," says Dr. Wallace, "by the operation of the sun, do sometimes generate several things; as some years since, some fishermen fishing half a league from land, over against Copinsha, in a fair day, there fell down from the air a stone about the bigness of a foot-ball, which fell in the middle of the boat, and sprung a leak, to the great danger of the lives of the men that were in it, which could be no other than some substance generated in the clouds. The stone was like condensed or petrified clay, and was a long time in the custody of Captain Andrew Dick, at that time steward of this country; and Captain Dick, who is yet alive, told me he gave it to the late Earl of Glencairn." From these particulars, we can entertain little doubt of the fact, however much we may be disposed to smile at the Doctor's facility of theorizing.

March 26. O. S. 1676. About an hour and three quarters after sun-set, a fire ball was seen to proceed, as if from Dalmatia, passing obliquely over Italy with a hissing noise, and exploding to the south south-west of Leghorn with a terrible report. Its fragments are said to have fallen into the sea, with the same sort of noise as when red hot iron is extinguished in water. Its greatest altitude in the south south-east at Bologna, was 38°, and its greatest at Siena, in the north north-west, was 58° On one side of the country it seemed to be nearly vertical, at Rimini and Savigniano, and at Leghorn on the other. Montanari professor of mathematics at Bologna, who published a treatise on this phenomenon, conjectures that the meteor must have moved at the rate of at least 160 miles in a minute. Its apparent magnitude at Bologna exceeded that of the full moon in one diameter, and was above half as big again in the other. Dr. Halley has condensed the substance of Montanari's Report, in No. cccxli. of the *Philosophical Transactions*.

May, 28, 1677. Many stony masses, supposed to have contained particles of copper, are said by Balduinus, in his Appendix to the *Miscellanea Naturæ Curiosorum*, for 1677, to have fallen near Ermendorf, in Saxony.—January 12, 1683, a mass of stone or iron fell near Castrovillari, in Calabria. *Mercati*.—March 3, 1683. A stone fell in Piedmont. *Id.*—1689.—Red dust fell at Venice, &c. *Valisnieri*—Jan. 3, 1697 In Soldani's catalogue, published in the 9th vol. of the *Transactions of the Academy of Sciences at Siena*, stones resembling those already described are said to have fallen at Pentolina, near Siena.—May 19, 1698. Scheuzer, in his *Natural History of Switzerland*, informs us that a black stone fell from the atmosphere, with various explosions, near the village of Waltring, in the canton of Berne, and that it was transmitted, with an account of the circumstances, to the public library at Berne. It is doubtful, however, if the stone preserved in that repository is the same which fell.—June 7, 1706, a stone, weighing 72 lb. is said to have fallen near Larissa, in Macedonia. It was observed to proceed from the north with a loud hissing, and enveloped in a small cloud, which exploded with a tremendous noise discharging a stone, which had the appearance of iron dross and the smell of sulphur. *Lucas*.—May 5 and 6, 1711. Red rain at Orsio, in Sweden. *Act. Liter. Suec.* A gelatinous matter fell with a globe of fire, in the isle of Lethy, in India. *Barchewitz*.—April 6, 1719, there fell into the Atlantic Ocean, in 45° Lat N. and 322° 45′ Long. from Paris, a shower of sand, which lasted from ten o'clock in the evening till one o'clock of the afternoon of next day. It was preceded by a luminous meteor. The wind was then east south-east. The captain of a vessel, and all the crew, certified the fact to Father Feuillée, who presented a specimen of the sand to the Academy of Sciences. It had the appearance of common, but very fine sand. June 5, 1722, stones fell near Scheftlas, in Freisengen. *Meichelbeck*—June 22, 1723 Dr. Rost (*Breslaw Collect*) relates, that at two o'clock in the afternoon, the weather being then calm, there was seen at Pleskowicz, some miles from Reichstadt, in Bohemia, a small cloud, from which several large and small stones were projected, under loud explosions but without any lightning. These stones, which were black on the outside had internally the appearance of metal, and exhaled a strong sulphureous odour. Twenty-five of them were collected in one place, and seven or eight in another. This instance is likewise noted by Stepling, *de Pluvia Lapidea*—July 22, 1727. Stones fell at Lilaschitz, in Bohemia. *Stepling*—1731. Fused metal fell at Lessay. *Halley*—August 18, 1738. Stones fell near Carpentras. *Castillon*—Oct. 25, 1740 Stones fell at Rasgrad *Gilb. An*—1740, or 1741. A large stone fell, during winter, in Greenland. *Egede*.—1743 Stones fell at Liboschitz, in Bohemia *Stepling*.—1744. Red rain at San Pietro d'Arena, near Genoa. *Richard*—October 12, 1750 M. de Lalande, the celebrated astronomer, informs us that a loud noise was heard in Lower Normandy, and that a very large mass of stone fell at Niort, in the vicinity of Coutances.

May 26, 1751, at six o'clock in the evening, a remarkable fire-ball was observed near Hraschina, in the district of Agram, in Upper Sclavonia. According to

Mr. Stutz, an intelligent naturalist, attached to the Imperial Cabinet of Vienna, this meteor burst asunder into two parts, exhibiting the appearance of twisted chains of fire, accompanied with smoke, rushing down with a dreadful explosion, and with such force as to shake the earth. The larger fragment, which weighed 71 lb. sunk to the depth of three fathoms, and made a breach of two feet, round which the soil was greenish, and seemed to be scorched with fire. The other, of only 16 lb. weight, fell in a meadow at 2000 paces from the first, and made an opening of four feet wide. The largest, which consists of native iron, and presents on its surface the most evident marks of fire, is preserved in the Imperial Cabinet of Natural Curiosities at Vienna, with an official attestation from the consistory of the bishopric of Agram, who interrogated several eye-witnesses A great many people in that part of the country heard the explosion, and likewise saw some fiery body fall from the sky, though, on account of the distance, they could not determine the precise spot. Dr. Chladni and Dr. Noehden mention, that they saw the larger mass in the Vienna museum; and the latter remarks, that it is not smooth and even on the outside, but rough, with depressions and protuberances, and destitute of the vitreous particles observable in the cavities of the Siberian iron. Klaproth's analysis gave of native iron 96.5, and of nickel 3.5—a composition nearly identical with the specimen of native iron brought by Humboldt from the province of Durango, in Mexico.

January 1753. A stone fell at Eichstadt, in Germany. *Cavallo.*—July 3 1753. Four stones, one of which weighed 13 lb fell at Strkow, near Tabor, at eight o'clock in the evening, when the air was tranquil, and the sky little shaded with clouds. Their fall was preceded by three loud and prolonged peals, like the discharge of artillery The people in the fields fled for terror to their houses or climbed up into the trees; and a shepherd, who applied his hand to one of the stones after it had fallen, felt it very sensibly heated. A fragment of one of them was distinctly labelled in the Bornian collection, with the additional annotation, *Quæ fragmenta 3tio Julii, 1753, inter tonitrua, e cælo pluisse creduliores quidam asserunt.* The expression of *creduliores quidam*, may be alleged to invalidate the purport of the label, yet it deserves to be remarked, that, in regard to the present subject of our inquiry, what was formerly accounted the credulity of the vulgar, may now, on several occasions at least, be construed into probability, if not into matter of fact, that Stepling reported the phenomenon only the year after it is stated to have taken place, and that the late Hon. Charles Greville, who procured the identical specimen from the Bornian collection, and Mr. Howard, found it to coincide in composition with other atmospheric stones; for its analysis gave,

Silica	45
Magnesia	17 27
Iron	42 72
Nickel	2.72
	107 7

Its specific gravity is 4.28. Another specimen is deposited in the Imperial Cabinet of Vienna

September, 1753. We have next to direct our attention to another report of M. de Lalande, inserted in the *Historical Almanack of Bresse*, for 1756. About one o'clock, P. M. when the weather was very hot, and very serene, without any visible trace of a cloud, a very loud noise, like the discharge of two or three cannons, was heard within the circumference of six leagues, but for a very short duration. This noise was loudest in the neighbourhood of Pont-de-Vesle; and at Liponas, a village three leagues from the last mentioned place, it was even accompanied by a hissing like that of a cracker. On the same evening there were found two blackish masses, of a form nearly circular, but very uneven, which had fallen, the one at Liponas, and the other at Pin, into ploughed ground, and sunk, by their own weight, to half a foot beneath the surface. One of them weighed about 20 lb. and a fragment of the other weighing 11½ lb. was preserved in the cabinet of M. Varenne de Beost, at Dijon. The basis of these masses resembled a greyish trap, and was very refractory; and through the substance of the stone, and especially in its fissures, were disseminated some ferruginous particles in grains, filaments, or minute nodules. This iron, when subjected to a red heat, became obedient to the magnet. The black coating on the surface M. de Lalande ascribed to fusion, induced by violent heat. These circumstances, though slightly noticed, are strictly conformable to the history of more recent cases, which remain to be detailed.

July, 1755. A stone fell at Terra nuova, in Calabria, which weighed 7 oz. *Domin. Tata.*—October 20, 1755. A black dust, like lamp-black, fell in Shetland between three and four o'clock in the afternoon, when the sky was very hazy. This dust smelled strongly of sulphur, and covered the faces and hands, and blackened the linen of the people in the fields. As the wind blew from the south-west, it is not probable that it was ejected from Hecla, which is situated between 500 and 600 miles farther north. *Phil. Trans.* vol l.—Nov. 15, 1755 A red sky, and the fall of red rain, in several countries. *Nov Act Nat Cur* t. ii —Oct. 9, 1763 Red rain at Cleves, Utrecht, &c. *Mercurio. Histor. Polit* —Nov. 14, 1765. Red iron in Picardy. *Richard.*—End of July, 1766. When the sky was clear at Albereto, in the neighbourhood of Milan, it was dark and cloudy in the direction of the western hills, and in the valley to the north, with frequent thunder and lightning. About five o'clock in the evening, when the peasants were dispersed over the fields, engaged in their rural labours, there was suddenly heard, not only in Albereto, but in other places at a considerable distance to the west, and even at Modena, an unusual noise, like the discharge of artillery, succeeded by a whizzing in the air, like that produced by a cannon bullet when powerfully propelled. The Duke of Modena's gardener even believed that a cannon ball was descending into the garden. Others either did not hear the whizzing noise, or had not paid attention to it. In Albereto, however, it was not only heard, but a body was moreover seen traversing the air with great velocity, and falling abruptly to the earth. To some of the distant bystanders it appeared in a state of ignition; but to two ladies, who were within a mile of the spot, it seemed opaque and smoaking. They instinctively clung to a branch of a tree, but an ox, which was near them, fell to the ground from terror. The stone, which diffused an odour of sulphur, had penetrated the soil to nearly the depth of a fathom, was still hot when taken up, and had the appearance of a sandstone of great weight, of an irregular triangular figure, with its external surface uniformly burnished over with black, as if from the effect of fire. The person who took it up broke it into pieces, and the fragments were distributed among different people in the town. Father Troili, who relates these circumstances, as they were communicated to him by eye-witnesses, and particularly by the individual, who, with the assistance of a young peasant, extracted the stone from the earth, published in the course of the same year a curious treatise, entitled, *Della Caduta di un Sasso dall'Aria Ragionamento*, &c. in which he adduces many excellent arguments to prove not only his own assertions, but the truth of the general doctrine of the descent of meteorites on various occasions. But we cannot learn that the reasoning of the Jesuit produced much impression on the public mind; and certainly it had no weight with men of science. At the distance of half a century, however, the book has been eagerly coveted by the learned; and a copy, with the perusal of which we have been politely favoured by Thomas Allan, Esq. of this city, belongs to that gentleman's valuable repository. Vassalli, in his *Physico Meteorological Letters*, alludes to the fall of the Albereto stone; and Beccaria likewise adverts to it in the postscript of his letter to Dr. Franklin, entitled, *De Electricitate Vindice*, having apparently procured his information of the fact from Fogliani, bishop of Modena, a highly respectable character, and a zealous naturalist. —August 15, 1766. Between six and seven o'clock P. M. a small stone fell near Novellara, at a little distance from a poplar that was struck at the same time by lightning. But if Troili, who mentions the fact, be correct in his conjecture, it was a piece of the bark of the poplar vitrified by lightning,—a supposition which seems to be scarcely admissible.

Sept. 13, 1768. The Abbé *Bachelay* acquaints us, that, about half past four o'clock in the afternoon, there appeared near the castle of Chevalerie, in the neighbourhood of Lucé, a small town in the province of Maine, a stormy cloud, from which proceeded a peal of thunder, like the discharge of a cannon, which was succeeded by a sound so similar to the lowing of cattle, as to impose on several people who heard it, in a circuit of two leagues and a half, but unaccompanied with any perceptible flame. Some reapers, in the parish of Perigué, about three leagues from Lucé, on hearing the same noise, looked up, and saw an opaque body, which described a curve, and fell on soft turf on the high road, near which they were at work. They all quickly ran up to it, and found a sort of stone, nearly half of which was buried in the earth, and the whole so hot that it could not be touched. At first they fled in a panic; but, on returning to the spot some time after, they found the mass precisely in the same situation, and sufficiently cooled to admit of being handled and narrowly examined. It weighed seven pounds and a half, and was of a triangular form, presenting as it were three rounded horns, one of which, at the moment of the fall, had entered into the ground, and was of a grey or ash-colour, while the rest which was exposed to the air was very black. When the Abbé presented this stone to the Academy of Sciences, that body appointed Messrs. Lavoisier, Fougeroux, and Cadet, a committee, to examine and analyse it, a task which they performed with more care and accuracy than M. de Lalande had done on a preceding occasion; but their trial was limited to an integral part of the whole, considered as a homogeneous substance, in place of being applied to each of the constituent parts. The result was

Silica	55.5
Iron	36
Sulphur	8
	99.5

The substance of the stone was of a pale ash-grey, speckled with an infinite number of minute and shining metallic points, visible through a magnifying glass. The thin black outer coating, which seemed to have been fused, alone gave a few sparks when struck with steel. Its specific gravity was 3.58. From the few small fragments of this meteorite which have been preserved, it seems to be nearly allied to those from Benares. The committee, very unwilling to allow that it could have descended from the air, conjectured that it had previously existed in the ground, and had merely been struck by the electric flash. The singular position in which it was found, however, with one of its angles inserted in the turf, was most likely not a permanent one: and really with respect to a matter of fact, subject to the cognizance of the senses, we may believe a rustic spectator, in preference to a philosopher who speculates in his closet.

Another stone, of nearly the same composition, accompanied by the history of its fall at Aire, in Artois, was presented to the academy in the course of the same year, by M. Gusson de Boyaval, honorary lieutenant-general of the bailliage of Aire, to which was added, by the younger Morand, the specimen from Coutances. According to the academical report, these three stones, when compared, presented no difference to the eye, being of the same colour, and nearly of the same grain, interspersed with metallic and pyritous particles, and covered with a black and ferruginous incrustation. Their common aspect did not convince the academy that they had been conveyed to the earth, yet the coincidence of the attested circumstances in three places, distinctly separated from one another, and the characters which discriminated them from other stones, induced the learned body to announce their history, and to invite its discussion.

November 20, 1768. A stone fell at Mauerkirchen, near the Inn, in Bavaria, at four o'clock, P. M. which weighed thirty-eight pounds. It was of a triangular form, and eight inches in thickness. Its fall was proclaimed by a hissing noise, and great darkness in the air, and it penetrated two feet and a half into the soil. *Imhof, in Gilb. An.*—A detached fragment is preserved in the Imperial Cabinet of Vienna, another in the Grevillian Collection, and another in that of Robert Ferguson of Raith, Esq.

November 17, 1773, the Captain general of Saragossa dispatched the following letter, accompanied with the stone to which it refers, to Don Manuel de Roda, Minister of State.

"In November last, an extraordinary occurrence, said to have happened on the 17th of that month, in a ploughed field at Sena, a village in the district of Sigena, was the topic of conversation in this city.

"The sky being perfectly serene, three reports, resembling those of cannon, were heard, and followed by the fall of a stone, weighing nine pounds and one ounce, at a little distance from two labouring men. One of them went up to it; but the strong smell which it emitted stopped him for a moment.

"Recovering from his surprise, he went nearer, heaved it up with his spade, and waited till it was sufficiently cold for him to carry it to the village, where he delivered it to the priest.

"From inquiries made immediately afterwards on the spot, and among the people in the neighbourhood, it appears that the noise in the air and fall of the stone were not accompanied with any storm or with lightning."

This stone is still preserved in the Royal Collection at Madrid. Professor Proust, who was allowed to analyse it, on condition of leaving the principal portion untouched for the gratification of the curious, has favoured the public with several particulars relative to its texture and aspect. When delivered to him, it weighed six pounds ten ounces. Along with it was a piece of three or four ounces, the only one remaining of those which had been broken from it by the inquisitive. It was interspersed with spots of rust, both externally and internally, owing probably to its having been immersed in water, to try the effect of that fluid on its composition. Its shape was an irregular oval, seven or eight inches long, four or five broad, and four in its greatest thickness. One side was flattish, a little depressed in the middle, and much rounded on the edges. It appeared to have had the black vitreous crust common to stones of this kind, though from its fragility the greater part had fallen off in passing through many hands, and receiving occasional blows, so that none remained except in the hollow of the base, and a little on the faces of the pyramid. On examining this crust, it was judged to be the effect of heat, powerful, though momentary, because the metallic and sulphureous particles immediately beneath the crust had not had time to change colour, or even to lose their lustre. It had the porousness of an aggregate mass of arenaceous particles, without any cement, so that the breath would easily pass through a piece held between the teeth; nor did it give sparks with steel. Its colour was a uniform bluish-grey, like that of a black substance, enlightened by a white one, or like the hue of an earthy compound, tinged by the least oxydation of iron. The rounded oval grains, of which the mass was composed, were very small, the largest being scarcely bigger than hempseed, among which were sprinkled metallic and sulphureous particles, characterized by that light tint of kupfernickel, observable in most meteorites. The microscope ascertained that the earthy grains, so far from having been fashioned by the movement of water, were globules, rough with crystalline or reflecting points, so that they could not be confounded with common sand. A piece of about two inches being exposed to a red heat, in a crucible, for half a quarter of an hour, was much changed; for the sandy globules became of a darker grey, and the metallic particles, deprived of their lustre, were sensibly oxidized. About two ounces were heated for half an hour, in a forge fire, which converted the stone into a semi-vitreous mass, blackish, slightly porous, and interspersed with globules of iron, which had not time to precipitate, though upwards of 100 grains of regulus were collected at the bottom. The magnetic iron was not uniformly mixed in the mass, as some parts yielded 22, and others only 17 per cent. This iron was combined with nickel, in the proportion of about 3 per cent.; but no nickel was traceable in any other part of the stone. After this alloy was separated by the magnet, the remainder was found, by analysis, to contain of

Iron, sulphureted at a minimum,	12
Black oxyd of iron,	5
Silex,	66
Magnesia,	20
Lime and magnesia in quantities too small for appreciation.	
	103

A fragment kept for twelve hours under water, was taken out, covered with spots of rust, which distinguished the grains of alloy from the sulphureous particles with which they were formerly confounded.

September 19, 1775. A stone, which is still preserved in the Cabinet of Natural History at Cobourg, fell near Rodach, a village in the principality of that town. *Gilb. An.*—1775, or 1776. Stones fell near Obruteza, in Volhynia, *Id.*—January or Feburary 1776, a great shower of stones fell near Fabbriano, in the territory of Santanatoglia, the ancient duchy of Camerino. *Soldani* and *Amoretti.*—1779. Mr. Bingley relates, in the *Gentleman's Magazine*, that he has in his possession two pieces of an atmospheric concretion, which actually descended in a loud peal of thunder on a meadow at Pettiswood, in the county of Westmeath, Ireland. They weigh three ounces and a half, and are supposed to have formed two-thirds of the whole mass, which in shape resembled a twopenny heart-cake. "At the instant this rude lump descended," says Mr. Bingley, "our little village was enveloped with the fumes of sulphur, which continued about six minutes. To its descent five witnesses are now living, three of whom reside in London. It lighted upon the wooden part of a harness, called a stradle, belonging to a filly drawing manure to a meadow, and broke into three pieces. At the same instant the affrighted beast fell to the earth under her load; as did the two equally affrighted gassoons (boys,) the drivers, who in *good Irish* came crying to me with two pieces of the stone, declaring that themselves and the filly were all *murdered by this thunder bolt*; none of whom, however, have received the least injury. The two pieces, when I received them after the *resurrection* of the boys, were warm as milk just from the cow; whence it may naturally be concluded that the cake came from a scorching atmosphere, and pretty well accounts for the outside of it in its formation, and during its stay there, having been tinged to a whitish brown, whereas internally it is of a silver white."—April 11, 1780. Stones fell near Beeston, in England. *Loyd's Evening Post.*—April 24, 1781. Count *Gioeni* observed in the third region of Mount Etna, every thing to be wetted with a cretaceous grey rain, which, after evaporation, left every part covered with it, to the height of two or three lines. All iron work touched by it became rusty. *Philos. Trans.* vol. lxxii.—1782. A stone fell near Turin. *Tata* and *Amoretti.*—February 19, 1785. Baron *Moll*, in a German publication, has communicated some notices of stones which fell in the principality of Eichstaedt. One of the masses transmitted to Baron Hompesch had the aspect of a grey ash-coloured sandstone, speckled with small grains of both malleable and ochreous iron. A brickmaker saw it fall when the ground was covered with snow, and immediately consequent on what he termed a loud peal of thunder. On running to lay hold on it, he felt it so hot, that he was obliged to let it cool in the snow in which it was immersed. This specimen was about half a foot in diameter, and completely enveloped in a black vitrified incrustation of native iron, ten lines in thickness, which indicated the action of fire. It yielded to Klaproth,

Silex	37
Magnesia	21.5
Iron	16.5
Oxyd of do. . . .	19
Nickel	1.5
Sulphur, a trace.	
	96.5

A specimen may be seen in the Imperial Cabinet of Vienna. See also *Pickel* and *Stutz*.—October 1, 1787. Stones fell in the province of Charkow, in Russia. *Gilb. Ann.*

July 24, 1790. The shower of stones which fell near Barbotan and other places in the *landes* of Bourdeaux, is worthy of particular commemoration. The fiery meteor from which it proceeded, and which was seen at Agen, and in the neighbouring departments, about nine o'clock in the evening, after traversing a certain portion of the atmosphere, and dragging a luminous train, which was visible for at least 50 seconds, exploded with an extraordinary noise and scintillation. Of the numerous accounts of this phenomenon, some of the most interesting are addressed to M. Darcet, the chemist. An inhabitant of St. Sévère, for example, imparts the ensuing circumstances.

"Yesterday our town's people were agitated by a very unusual alarm. About a quarter past nine o'clock, there suddenly appeared in the air a fire-ball, dragging a long train, which spread a very vivid light over the horizon. This fire-ball soon disappeared, and seemed to fall at one hundred paces from us. Soon after we heard an explosion, much louder than that of cannon or of thunder. Every body dreaded being buried under the houses, which threatened to give way, from the violence of the concussion. The same phenomenon was seen, and the report heard in the neighbouring towns, such as Mont du Marsan, Tartas, and Dax. In other respects the weather was very calm, without a breath of wind or a cloud, and the moon shone in all her brightness."

M. Darcet's brother, a clergyman in that part of the the country, sent him a small stone, which was picked up on the morning after the explosion, and the history of which he was scrupulously anxious to investigate. Being satisfied with respect to all the particulars, he dispatched it to Paris, accompanied with some curious remarks. "When the stones fell," he observes, "they had not their present degree of hardness. Some of them fell on straw, bits of which stuck to the stones, and incorporated with them. I have seen one in this predicament. It is at present at la Bastide, but I cannot persuade the owner to part with it.... Those which fell on the houses, produced a noise not like that of stones, but rather like that of a substance which had not yet acquired compactness."

We shall also cite the *procès verbal*, a simple but authentic document.

"In the year one thousand seven hundred and ninety, and the 30th day of the month of August, we, the Sieur Jean Duby, Mayor, and Louis Maullon, Procurator of the Commune of the Municipality of La Grange de Juillac, and Jean Darmitte, resident in the parish of la Grange de Juillac, certify in truth and verity, that on Saturday the 24th of July last, between nine and ten o'clock, there passed a great fire, and after it we heard in the air a very loud and extraordinary noise; and about two minutes after there fell stones from heaven; but fortunately there fell only a very few; and they fell about ten paces from one another in some places, and in others nearer, and finally in some other places farther, and falling, most of them of the weight of about half of a quarter of a pound each; some others of about half a pound, like that found in our parish of la Grange; and on the borders of the parish of Creon, they were found of a pound weight, and in falling they seemed not to be inflamed, but very hard and black, without and within, of the colour of steel; and, thank God, they occasioned no harm to the people nor to the trees, but only to some trees which were broken on the houses; and most of them fell gently, and others quickly, with a hissing noise; and some were found which had entered into the earth, but very few. In witness whereof we have written and signed these presents.

Duby, *Mayor;* Darmitte."

M. Baudin states, that as Mr. Carris and he were walking in the court-yard of the castle of Mormés, about half past nine o'clock in the evening, when the air was quite calm, and the sky cloudless, they found themselves suddenly surrounded by a pale clear light, which diminished that of the nearly full moon. On looking up, they observed, almost in their zenith, a fire-ball of a larger apparent diameter than that of the moon, dragging a tail five or six times longer than its body, and which gradually tapered to a blood red point, while the rest of the meteor was of a pale white. The direction of this luminous body, which proceeded with great velocity, was from south to north. In about two seconds, it split into portions of considerable size, which fell in different directions, like the fragments of a bomb that bursts in the air. These fragments became extinguished before they reached the ground, and some of them, in falling, assumed that blood red colour which had been observed at the point of the tail. Two or three minutes after, they heard a dreadful explosion, like the simultaneous firing of several pieces of ordnance. The concussion of the atmosphere produced effects similar to those of an earthquake; for windows shook in their frames, and kitchen utensils were thrown down from their shelves; but M. Baudin and his friend were not sensible of any motion under their feet. From the court of the castle these gentlemen went into the garden, when the noise still continued, and seemed to be directed over their heads. Some time after it had ceased, they heard a hollow sound rolling in echoes, for fifty miles, along the chain of the Pyrenees, continuing for four minutes, and gradually dying away in distance, the atmosphere all the time diffusing a sulphureous odour.

The interval which occurred between the bursting of the meteor and the loud report, induced M. Baudin to conjecture that the fire-ball must have been at least eight miles from the earth's surface, and that it fell about four miles from Mormés; and the latter part of his conjecture was confirmed by the fact. It appears, indeed, from the concurring relations of intelligent persons worthy of credit, that the meteor really exploded at a little distance from Juillac, and that the fallen stones, of different sizes, were found lying in an almost circular space of nearly two miles in diameter. Though some of them fell in courts and gardens, no houses were materially injured; but, in the neighbouring woods, some branches were broken and torn off. According to some of the accounts, one of the stones fifteen inches in diameter, broke through the roof of a cottage, and killed a herdsman and a bullock. People deserving of credit, mentioned that one of four pounds had fallen near a farmer's door; and another, which weighed between twenty and twenty-five pounds, was carried as a curiosity to the town of Mont-du-Marsan. Though generally smooth on the outside, they presented some longitudinal cracks or fissures, while their internal substance, transversely striated, exhibited indications of metallic veins, especially of a ferruginous complexion. When yet red hot, and scattered in various directions, they formed that magnificent fire-work, that shower of flame, which illuminated the horizon over a large track of country. The meteor is supposed to have been perpendicular to Juillac, since at Dax, situated to the south-west of Messin, it was perceived in the north-east. It was seen at Bayonne, Auch, Pau, Tarbes, and even at Bourdeaux and Toulouse, though at the last mentioned place it excited little attention, on account of its great distance, and its appearing only a little brighter than a shooting star.

When all the circumstances of the case are duly considered, we need not be surprised that the publication of them should produce conviction on the minds of many men of science, who had avowed their disbelief in every thing of the kind. In fact, when we are presented with the joint testimony of the learned and unlearned of the district, in which the phenomenon is stated to have occurred, when we find the Professor of Natural History in the central school of Agen retracting his former scepticism, and the accurate and skilful Vauquelin revealing the same chemical substances which he had detected in other atmospheric stones, and nearly in the same proportions, it would be highly unreasonable to withhold our assent, merely because we have not in person witnessed the particulars. The few apparent discrepancies which may be observed in the different accounts, are all capable of an easy solution, and ought in no respect to invalidate the testimony in favour of the general fact; yet, it is not a little singular that different narratives, published at no great distance of time subsequent to the event, assign to it erroneous dates, some placing it in 1789, others in 1791, some in August, and others in September. Specimens of the Barbotan stones are not uncommon in the collections of the curious.

May 17, 1791. Stones fell at Castle Berardenga, in Tuscany. *Soldani.*—June 16, 1794, the late *Earl of Bristol's* account of the Siena meteorite is thus related by the late *Sir William Hamilton*, in the *Philosophical Transactions* for 1795.

"I must here mention a very extrordinary circumstance indeed, that happened near Siena, in the Tuscan State, about eighteen hours after the commencement of the late eruption of Vesuvius, on the 15th of June, although that phenomenon may have no relation to the eruption; and which was communicated to me, in the following words, by the Earl of Bristol, Bishop of Derry, in a letter, dated from Siena, July 12, 1794. 'In the midst of a most violent thunder storm, about a dozen stones of various weights and dimensions fell at the feet of different people, men, women, and children; the stones are of a quality not found in any part of the Sienese territory; they fell about eighteen hours after the enormous eruption of Vesuvius, which circumstance leaves a choice of difficulties in the solution of this extraordinary phenomenon; either these stones have been generated in this igneous mass of clouds, which produced such unusual thunder; or, which is equally incredible, they were thrown from Vesuvius, at a distance of at least 250 miles; judge then of its parabola. The philosophers here incline to the first solution. I wish much, sir, to know your sentiments. My first objection was to the fact itself; but of this there are so many eye-witnesses, it seems impossible to withstand their evidence, and now I am reduced to perfect scepticism.' His lordship was pleased to send me a piece of one of the largest stones, which, when entire, weighed upwards of five pounds; and I have seen another, which has been sent to Naples entire, and weighs about one pound. The outside of every stone that has been ascertained to have fallen from the cloud near Siena, is evidently freshly vitrified, and is black, having every sign of having passed through an extreme heat; when broken, the inside is of a light grey colour, mixed with black spots, and some shining particles, which the learned here have decided to be pyrites; and, therefore, it cannot be a lava, or they would have been decomposed."

The Abbate *Soldani*, Professor of Mathematics in the University of Siena, has published a more detailed account of the same phenomenon. He informs us, that an alarming cloud was seen in Tuscany, near Siena and Radacofani, proceeding from the north, about seven o'clock in the evening, discharging sparks like rockets, and throwing out smoke like a furnace, with explosions more resembling the discharge of cannon and musketry than thunder, and casting down ignited stones to the ground, while the lightning which issued from it was remarkably red, and less rapid than an ordinary flash. To persons in different situations, the cloud appeared to be of different shapes; and, though it remained suspended for a considerable time, its fire and smoke were visible in every direction. Its altitude, from a combination of cirumstances, was judged to be much above the common region of the clouds. One of the stones, which was of an irregular figure, weighed five pounds and a half, was black on the outside, as if suffused with smoke, and seems, internally, to be composed of matter of the colour of ashes, and in which were perceived small specks of metal, as of gold and silver. Besides this, about nineteen others were shown to Soldani, and all of them characterized by a black and glazed outer surface, by their resistance to acids, and by a degree of hardness which permitted them not to be scratched with the point of a penknife.

Signor *Montauli*, who observed the cloud as he happened to be travelling, described it as appearing much above the elevation of ordinary clouds, as wrapt in smoke and flame, and as gradually becoming white, without being visibly affected by the sun's rays, which beamed full on its lower portions. In the heart of it he could discern, as it were, the basin of a fiery furnace, with a rotatory motion. This curious observer likewise gives an account of a stone, which, he was assured, dropped from the cloud, at a farmer's feet, and was dug out of the ground into which it had penetrated. It was about five inches long, and four broad, nearly square, and smooth, black on the surface, as if singed, but, within, like a sand-stone, with various small particles of iron, and bright metallic stars. Most of the others which he examined were of a rudely trianglar shape, and some so small as not to weigh more than an ounce.

The ladies at Cozone, about twenty miles from Siena, saw a number of them come down with a great noise, in a neighbouring meadow; and one of them, which was soon after taken up by a young woman, burned her hand; another burned a peasant's hat; a third struck off a branch from a mulberry-tree; and a fourth very nearly hit a girl who was tending a flock of sheep. At Cozone, however, the stones were of a small size, and accompanied with the fall of sand; thus intimating a close connection between meteorites and showers of sand.

The specific gravity of the Siena stones was found to be about 3 3, or 3 4; and one of them, treated by Mr. Howard, as particularly detailed in the 92d vol. of the *Philosophical Transactions*. yielded,

Silica, ...	46 66
Magnesia, ...	22.67
Iron, ...	34.67
Nickel	2
	106

A pretty entire specimen occurs in Mr. Ferguson's collection.

The preceding case affords a striking example of the different manner in which we regard a phenomenon by itself, and the very same phenomenon, when we consider it in connection with others. The naturalits of Siena, aware that the stones had fallen after one of the most violent tempests, and on the day immediately subsequent to one of the most formidable eruptions of Vesuvius, were inclined to view it as electrical or volcanic; and Soldani stood almost single in the opinion, that the appearance was independent of the eruption. But they who now contemplate the same fact in its relation with so many others, who know that the Siena stones present both the same physical characters, and the same chemical results with others which are ascertained to have fallen in different parts of the world, when not a breeze or a cloud interrupted the serenity of the weather, are decidedly convinced that it has no reference to any volcanic eruption, or to any ordinary storm.

April 13, 1795. Stones fell in Ceylon. *Beck*.

The circumstances attending the fall of the Yorkshire stone are thus detailed by Major *Topham:*

" The man, who, by some fortuitous circumstance, happens to possess any extraordinary curiosity, has a very troublesome companion. It was my good fortune to tumble into this predicament by a stone falling near my house in the country: and though I have been called upon, both publicly and privately, for a thousand accounts, and have answered innumerable inquiries, I was resolved to consign the stone in question to some public museum, and to deliver with it the most accurate account I was able to take from living witnesses on the spot, as I was at that time engaged on business in London. The stone, therefore, will no longer ' blush unseen,' but be subject to be examined by every philosopher in the united kingdom, who may choose to visit the *Museum of Mr. Sowerby*....

" Having premised thus much, I shall proceed to state what circumstances attended the falling of the stone in question, which was witnessed by many people who could have no interest in fabricating a false account, and were far too simple to have done so. What is most singular is, that it should have been so well attested, because, on the high wolds of Yorkshire, thousands of stones might have fallen, and there might not have been even a solitary shepherd, or his more solitary dog, to have witnessed the occurrence.

" It was on Sunday, about three o'clock, the 13th of December, in the year 1795, that the stone in question fell within two fields of my house. The weather was misty, and, at times, inclining to rain; and though there was some thunder and lightning at a distance, it was not till the falling of the stone that the explosion took place, which alarmed the surrounding country, and which created so distinctly the sensation that something very singular had happened.

" When the stone fell, a shepherd of mine, who was returning from his sheep, was about 150 yards from the spot; George Sawden, a carpenter, was passing within 60 yards; and John Shipley, one of my farming servants, was so near the spot where it fell, that he was struck very forcibly by some of the mud and earth raised by the stone dashing into the earth, which it penetrated to the depth of twelve inches, and seven afterwards into the chalk rock, making in all a depth of nineteen inches from the surface.

" While the stone was passing through the air—which it did in a north-east direction from the sea coast—numbers of persons distinguished a body passing through the clouds, though not able to ascertain what it was; and two sons of the clergyman of Wold Newton (a village near me) saw it pass so distinctly by them, that they ran up immediately to my house, to know if any thing extraordinary had happened.

" In the different villages over which the stone took its direction, various were the people who heard the noise of something passing through the air, accurately and distinctly, though they could not imagine what was the cause of it; and in many of the provincial newspapers, these accounts were published at the time from different persons.

" In fact, no circumstance of the kind had ever more concurrent testimonies; and the appearance of the stone itself, while it resembles in composition those which are supposed to have fallen in various other parts of the world, has no counterpart or resemblance in the natural stones of the country.

" The stone, in its fall, excavated a place of the depth before mentioned, and of something more than a yard in diameter. It had fixed itself so strongly in the chalk rock, that it required some labour to dig it out.

" On being brought home, it was weighed; and the exact weight, at the time, was 56 pounds; which has been diminished in a small degree at present, by different pieces being taken from it as presents to different *literati* of the country. All the three witnesses who saw it fall, agree perfectly in this account of the manner of its fall, and that they saw a dark body passing through the air, and ultimately strike into the ground; and though, from their situation and characters in life, they could have no possible object in detailing a false account of this transaction, I felt so desirous of giving this matter every degree of authenticity, that, as a magistrate, I took their accounts upon oath, immediately on my return into the country. I saw no reason to doubt any of their evidence, after the most minute investigation of it."

Of a hundred and sixty-two parts of the composition of the Yorkshire stone, Mr. Howard found,

Silica, ...	75
Magnesia, . . .	37
Oxide of iron, .	48
Oxide of nickel, .	2
	162

M. de Drée, we may add, found it to correspond exactly, in aspect and character, with the meteoric fragments from Benares and Villefranche, of which mention will be made in the sequel.

January 4, 1796. Stones fell near Belaia-Ferkua, in Russia. *Gilb. An.*—February 19, 1790 The ensuing relation is extracted from Mr. Southey's *Letters from Spain and Portugal.*

"A phenomenon has occurred here within these few days, which we sometimes find mentioned in history, and always disbelieve. I shall make no comment on the account, but give you an authentic copy of the deposition of the witnesses before the magistrates.

"Elias Antonio, ordinary judge of the term of Evorah Monte, and inhabitant of the parish of Friexo, in the Herdade of Gayes, says, that, on the 19th day of February, (1796.) between one and two o'clock in the afternoon, he heard two reports, similar to those of the explosion of mines; after which he perceived a great rumbling noise, which lasted about two minutes. Looking up to the horizon, it was not obscured, neither was there any cloud or appearance from which he could conjecture the sound to have proceeded. He recollects, likewise, that the rumbling ran from north to east, the day being clear and serene.

"Gregorio Calado, labourer in the Herdade of Pazo, and term of Redondo, says, that he heard the abovementioned sound, and that a little while after, one of his servants, called Jose Fialho, brought him a stone of the colour of lead, weighing ten pounds, and irregular in its figure, which stone the said Jose Fialho had found in a meer of the Herdade called Pasquinha, in the term of Evorah Monte; for after the two reports and the rumbling sound, he heard some heavy body fall near him, and found this stone sunk in the ground, still warm, and the ground freshly moved. Four boys who were in the same part affirmed the same."

The evidence here adduced is not very circumstantial; yet, when taken in connection with similar cases, it tends to corroborate the general fact.

March 8 1796. After the fall of a fire-ball in Lusatia, there was found a viscid substance, having the consistency, colour, and odour of a brown varnish. Chladni, who procured a small portion of it, in a very dried state, conceived that it was principally composed of sulphur and carbon.

March 12, 1798 Concerning the stone which is reported to have fallen near Villefranche, in the department of the Rhône, we are presented with a great variety of details; but we shall notice only a few of the most important. When it was transmitted to M. Sage, Member of the National Institute, and Professor of the First School of Mines, he hastily considered it as only a pyritous and magnetical ore of iron, although it bore no resemblance to any known species of ore of that metal, since it contained nickel, silica, magnesia, and native iron, which, when the stone was polished, shone like steel. It was of an ash-grey colour, granulated, and speckled with grey shining metallic points. Its surface was covered on one side, with a dingy black enamel, about a third of a line in thickness; and it acted very powerfully on the magnetic needle. When the Senator *Chasset* sent it to M. Sage, it was accompanied with a historical notice of similar import with that which M. *Lelièvre* of Villefranche, who saw and described the phenomenon on the spot, had already communicated.

At six o'clock in the evening a round body, which diffused the most vivid light, was observed in the vicinity of Villefranche, moving westward and producing a hissing noise, like that of a bomb which traverses the air. This luminous body, which was seen at the same time at Lyons, and on Mont Cenis, marked its passage by a red track of fire, and exploded when about 200 toises from the earth, producing a loud report, and a commotion in the neighbourhood. One of the flaming fragments fell on the vineyard of Pierre Crepier, an inhabitant of Salés, making in the earth an opening of about twenty inches in depth, and eighteen in width. The analysis of Messsrs. Vauquelin and Howard first prompted M. Sage to examine this fragment and its history with more critical accuracy, and, finally, to renounce his scepticism with regard to the existence of meteoric concretions.

An account of the same meteor was published in the *Journal de Physique*, for Floreal, year 11, by *M. de Drée*, who visited the spot in 1802. From his minute and deliberate investigation, it appears, that, at the time above specified, a luminous and extraordinary globe, in the eastern quarter of the heavens, had scarcely arrested the attention of the inhabitants of Salés, and the adjacent villages, when its rapid approach, accompanied by a terrible whizzing noise, like that of an irregular hollow body, traversing the atmosphere with unusual velocity, inspired the whole commune with alarm, especially when they observed it passing over their heads, at an inconsiderable elevation, leaving behind it a long train of light, and emitting, with an almost unceasing crackling, small bright flames, like little stars. Its fall was remarked by three labourers, at the distance of only fifty paces. Montillard, one of the three, a young man, who happened to be next the falling body, was struck with terror, and threw down his coat and bundle of sticks, that he might run the faster. The other two, Chardon and Lapoces, fled, with equal precipitation, to Salés, where the alarm had become general. These three witnesses attest the astonishing rapidity of the meteor's motion, and the hissing which proceeded from the spot where it fell. Crepier, who happened to be at home, was so much terrified with the noise of its fall, within twenty yards of his house, that he locked himself up with his family, first in his cellar, and then in his private apartment, whence he ventured not to stir till next morning, when he was called to join Chardon, Lapoces, M. Brandel, and many others who had repaired to the precise spot where they had seen the fire-ball enter into the earth; and there, at the bottom of a wide aperture, eighteen inches deep, including the whole thickness of the mould, they found a large black mass, of an irregularly ovoid form, having some resemblance to a calf's head, completely incrusted with a black varnish, cracked in several places, and smelling of gun-powder. It was first of all brought to Crepier's house, and very closely examined: on breaking it, however, and observing nothing but stone, indifference succeeded to the curiosity of the observers; and they coolly attributed its appearance to causes more or less supernatural.

The simplicity of most of the accounts, their perfect agreement in every important point, and the number and integrity of the witnesses, removed all doubt and suspicion from the mind of M. de Drée.

The weight of the Villefranche stone, before it was broken, was about twenty pounds. Its black, vitrified, and opaque surface, gave fire with steel. Within, it was hard, earthy, of the colour of ashes, of a granulated texture presenting different substances scattered through it, viz. iron, in grains, from the smallest visible size to a line, or even more, in diameter, somewhat malleable, but harder and whiter than forged iron, white pyrites, both lamellar and granular, and approaching, in colour, to nickel, some grey globules, which seemed to present the characters of trap, and a very few and minute particles of steatite, inclining to an olive hue. On account of its heterogeneous composition, its specific gravity could not be easily ascertained. One hundred parts of the mass gave, according to Vauquelin,

Silica, . . .	46
Oxyd of iron, . .	38
Magnesia, . .	15
Nickel, . . .	2
Lime, . . .	2
	103

The excess of this result was ascribed to the absorption of oxygen, by the native iron, during the process.

December 19, 1798. About eight o'clock in the evening, a very luminous meteor, in the form of a large globe of fire, and accompanied by a loud thundering noise, was observed in the heavens by the inhabitants of Benares, and the parts adjacent. It was said to have discharged a number of stones near Krakhut, a village on the north side of the river Goomty, about fourteen miles from Benares. This meteor appeared in the western quarter of the hemisphere, and was visible only for a short time, to several Europeans, as well as natives, in different parts of the country. In the neighbourhood of Juanpoor, about twelve miles from the spot where the stones fell, it was distinctly perceived by various European ladies and gentlemen, who described it as a large ball of fire, accompanied by a rolling noise, which they compared to bad platoon firing. Mr. Judge *Davis* observed the light to come into the room which he occupied, through the casement, and so strongly as to project shadows very distinctly on a dark-coloured carpet.

When intelligence of the event reached Benares, Mr. Davis dispatched a judicious person to make the requisite inquiries. The natives, on being interrogated, mentioned, that they had either broken to pieces, or given to the collector and others, all the stones which they had gathered, but that others might still be found in the fields, by observing where the earth appeared to be recently turned up. Four were accordingly procured and brought to Mr. *Davis*. They had sunk about six inches deep into fields, which seemed to have been freshly watered, and about the distance of a hundred yards from one another. The person deputed to obtain information, was likewise told by the inhabitants of the village, that, about eight o'clock in the evening, when they had retired to their dwellings, they observed a very brilliant light, proceeding as from the sky, accompanied by a loud peal of thunder, which was immediately followed by the noise of heavy bodies falling in the neighbourhood. Uncertain whether some of their deities might not be concerned in this occurrence, they did not venture out till next morning, when the first circumstance which attracted their attention was the broken appearence of the surface of the ground: and further investigation corroborated these particulars. Mr. M'Lane, a gentleman who resided hard by Krak-hut, gave Mr. Howard part of a stone, which had been brought to him by the watchman who was on duty at his house. This, he said, had fallen through the top of his hut, which was close by, and buried itself several inches in the floor, which was of hardened earth. At the time that this meteor appeared, the sky was perfectly serene, and not a cloud had been seen since the 11th of the month, nor had any been observed for many days after.

"Of these stones," says Mr. Howard, "I have seen eight, nearly perfect, besides parts of several others, which had been broken by the possessors, to distribute among their friends. The form of the more perfect ones appeared to be that of an irregular cube, rounded off at the edges; but the angles were to be observed on most of them. They were of various sizes, from about three to upwards of four inches in their largest diameter; one of them, measuring four inches and a quarter, weighed two pounds twelve ounces. In appearance they were exactly similar: externally, they were covered with a hard black coat, or incrustation, which, in some parts, had the appearance of varnish, or bitumen; and on most of them were fractures, which, from their being covered with matter similar to that of the coat, seemed to have been made in the fall, by the stones striking against each other, and to have passed through some medium, probably an intense heat, previous to their reaching the earth. Internally, they consisted of a number of small spherical bodies of a slate colour, embedded in a whitish gritty substance, interspersed with bright shining spiculæ, of a metallic or pyritical nature. The spherical bodies were much harder than the rest of the stone: the white gritty part readily crumbled, on being rubbed with a hard body; and on being broken, a quantity attached itself to the magnet, but more particularly the outside coat or crust, which appeared almost wholly attractable by it.

"It is well known there are no volcanoes on the continent of India; and, as far as I can learn, no stones have been met with in the earth in that part of the world, which bear the smallest resemblance to those above described."

The history of the Benares meteor, then, speaks too distinctly for itself to stand in need of commentary.

April 5, 1799. Stones fell at Batonrouge, on the Mississippi. *Belfast Chronicle of the War.*

April 5, 1800. At night, a body wholly luminous was seen to move over a portion of America with prodigious velocity. Its apparent size was that of a large house seventy feet long, and its elevation above the surface of the earth about 200 yards. It diffused a light little inferior to that of the sun; and those who saw it perceived a considerable degree of heat, but no electrical sensation. Immediately after it disappeared in the north-west, with a violent rushing noise, which in a few seconds was followed by a tremenduous crash, and a very sensible vibration of the earth. Search being afterwards made in the place where the burning body fell, every vegetable was found burnt, or greatly scorched, and a considerable portion of the earth's surface broken up.

"We have to lament," remarks Mr. Howard, "that the authors of this account did not search deeper than the surface of the ground. Such an immense body, though moving in a horizontal direction, could not but be buried to a considerable depth. Should it have been more than the semblance of a body of a peculiar nature, the lapse of ages may perhaps effect what has now been neglected, and its magnitude and solitary situation become the astonishment of future philosophers." *Philos. Mag.*

1801. M. *Bory de St. Vincent*, the ingenious author of *Voyage dans les quatres principales Isles des Mers d'Afrique*, relates, (tom. iii. p. 253,) that in consequence of particular instructions from M. Hubert, he had, when on the Isle aux Tonneliers, made diligent search for the fragments of a stone which had been broken, and employed in the construction of a wall. Of these fragments he discovered three; one about the size of a melon, but too fast locked in the plaster to be detached, and the other two about the size of an orange each, and which were easily separated. They all evidently belonged to the same mass, and, though their fracture had become rusty, one side of their external surface exhibited, like certain lavas, a dark and polished tint, while their identity with stones reputed atmospheric seemed to leave no doubt of their origin. In regard to their history, M. *Descombes* informed the author, that some time before, probably in the year 1801, the ladies of the district were walking on the quay during a beautiful moonlight night, when all of a sudden they perceived a luminous cloud advancing from the west, and exploding with a very loud noise like the report of a cannon, but much more hollow, disclosing at the same time a beautiful ball of fire, in appearance perfectly spherical, and about a foot in diameter. When it broke from the cloud in which it had been conveyed, it was supposed to be half a league from the shore, to which it tended in a uniformly slanting direction, till it seemed to fall on the Isle aux Tonneliers. Several persons in the island of Bourbon affirmed, that on the same day, and at the same hour, they observed a luminous point in the air which, from the path of its motion, could be no other than this globe of fire.

March 5 and 6, 1803. A shower of red snow fell at Pezzo, at the extremity of the Valle Camonica. It was preceded by a violent wind on the 5th. *Journal de Physique*, 1804.

April 26, 1803. The history of the extraordinary shower of stones at L'Aigle, in Normandy, first appeared in the ensuing artless communication from M. *Marais*, resident in that place, to his friend at Paris.

"*At L'Aigle, the* 13*th Floreal, year* 11.

"An astonishing miracle has just occurred in our district. Here it is, without alteration, addition, or diminution. It is certain that it is the truth itself.

"On Friday last, 6th Floreal, between one and two o'clock in the afternoon, we were roused by a murmuring noise like thunder. On going out, we were surprized to see the sky pretty clear, with the exception of some small clouds. We took it for the noise of a carriage, or of fire in the neighbourhood. We were then in the meadow, to examine whence the noise proceeded, when we observed all the inhabitants of Pont de Pierre at their windows, and in gardens, inquiring concerning a cloud, which passed in the direction of from south to north, and from which the noise issued, although that cloud presented nothing extraordinary in its appearance. But great was our astonishment when we learned, that many and large stones had fallen from it, some of them weighing ten, eleven, and even seventeen pounds, in the space comprized between the house of the Buat family (half a league north north-east of l'Aigle) and Glos, passing by St. Nicholas, St. Pierre, &c. which struck us at first as a fable, but which was afterwards found to be true.

"The following is the explanation given of this extraordinary event by all who witnessed it.

"They heard a noise like that of a cannon, then a double report still louder than the preceding, followed by a rumbling noise which lasted about ten minutes, the same which we also heard, accompanied with hissings caused by these stones, which were counteracted in their fall by the different currents of air, which is very natural in the case of such a sudden expansion. Nothing more was heard; but it is remarkable, that previously to the explosion, the domestic fowls were alarmed, and the cows bellowed in an unusual manner. All the country folks were much dismayed, especially the women, who believed that the end of the world was at hand. A labouring man at La Sapée fell prostrate on the ground, exclaiming, 'Good God! is it possible that thou canst make me perish thus? Pardon, I beseech thee, all the faults that I have committed.' The most trifling objects, in fact, might create alarm; for it is not improbable that history offers no example of such a shower of stones as this. The piece which I send was detached from a large one weighing eleven pounds, which was found between the house of the Buats and Le Fertey. It is said that a collector of curiosities purchased one of seventeen pounds weight, that he might send it to Paris. Every body in this country is desirous of possessing a whole stone, or a fragment of one, as an object of curiosity. The largest were darted with such violence, that they entered at least a foot into the earth. They are black on the outside, and greyish, as you see, within, seeming to contain some pieces of metal and nitre. If you are the first to know of what ingredients they are composed, you will inform us. One fell near M. Bois de la Ville, who lives hard by Glos. He was much afraid, and took shelter under a tree. He has found a great number of them of different sizes in his court-yard, his wheat fields, &c. without reckoning all those which the peasants have found elsewhere. Numberless stories, more or less absurd, have been circulated among the people. You know that our country is fertile in such tales. Cousin Moutardier sends one of these stones to Mademoiselle Hebert; and he is not less eager than we are to know how these substances can be compressed and petrified in the air. Do try to explain the process.

"The person who gave me the largest stone which I send to you, went to take it at the moment that it fell, but it was so hot that it burned him. Several of his neighbours shared the same fate in attempting to lift it.

"The elder Buat has just arrived, and desires us to add, that a fire-ball was observed to hover over the meadow. Perhaps it was wild-fire."

At the sitting of the Institute on the 9th of May, Fourcroy read a letter addressed to Vauquelin, from the town of L'Aigle, containing, among other details, the following:

On the 26th of April, about one o'clock, P. M. the sky being almost serene, a rolling noise like that of thunder was heard. It seemed to proceed from a single cloud which was on the horizon, and which the inhabitants beheld with uneasiness, when, to their great surprise and terror, explosions like the reports of cannon, sometimes single and sometimes double, were heard, along with a violent hissing,—phenomena which struck terror even into domestic animals; for the cows bellowed, and the poultry fled to a place of shelter. This noise was succeeded by the fall of a great number of stones of different sizes, weighing ten, eleven, and even seventeen pounds. The largest entered the earth to the depth of a foot. Several of these fell into the court-yard of M. Bois-de-la-Ville, and one of them very near him. Many curious persons collected some of them; and Fourcroy laid before the Institute one of the fragments, which, when compared with that of the Villefranche specimen, presented at the meeting by Pictet, greatly resembled it in every point, exhibiting the same colour, texture, and black crust; in a word, the fragments could not be distinguished from each other but by the size.

Lamarck then reported that he had received several letters, apprizing him of a fire-ball which had been seen to pass from east to west with great velocity on the same day, and at the same hour, at which the event alluded to took place. It was added, that this meteor had been seen at sea before it reached the continent.

But we pass to the substance of M. Biot's letter, addressed to the minister of the interior, and published in the *Journal des Debats*. This gentleman, who is advantageously known over Europe for his scientific attainments, was deputed by government to repair to the spot, and collect all the authentic facts. The contents of his letter have been since expanded into the form of a memoir, which manifests the caution and judgment that guided his inquiries.

M. Biot left Paris on the 25th of June, and, in place of proceeding directly to L'Aigle, went first to Alençon, which lies fifteen leagues to the west south-west of it. On his way, he was informed that a globe of fire had been observed moving towards the north, and that its appearance was followed by a violent explosion. From Alençon he journeyed through various villages to L'Aigle, being directed in his progress by the accounts of the inhabitants, who had all heard the explosion on the day and at the hour specified; and almost all the residents of twenty hamlets declared, that they were eye-witnesses of a dreadful shower of stones which was darted from the meteor. The summary of the evidence which M. Biot collected, may be thus expressed.

About one o'clock, P. M. the weather being serene, there was observed from Caen, Pont-d'Audemer, and the environs of Alençon, Falaise and Verneuil, a fiery globe of uncommon splendour, and which moved in the atmosphere with great rapidity. Some moments after, there was heard at L'Aigle, and for thirty leagues round in every direction, a violent explosion, which lasted five or six minutes. Three or four reports, like those of cannon, were followed by a kind of discharge, which resembled the firing of musketry; after which, there was heard a dreadful rumbling, like the beating of a drum. The air was calm, and the sky serene, with the exception of a few clouds, such as are commonly observed at that season. The noise proceeded from a small cloud which had a rectangular form, the largest side being in a direction from east to west. It appeared motionless all the time that the phenomenon lasted; but the vapours of which it was composed were projected momentarily from different sides, by the effect of the successive explosions. This cloud was about half a league to the north north-west of the town of L'Aigle, and at a great elevation in the atmosphere; for the inhabitants of two hamlets, a league distant from each other, saw it at the same time above their heads. In the whole district over which this cloud was suspended, there was heard a hissing noise, like that of a stone discharged from a sling; and a great many mineral masses, exactly similar to those distinguished by the name of *meteor-stones*, were seen to fall.

The portion of country in which these masses were projected, forms an elliptical extent of nearly two leagues and a half in length, and nearly one in breadth, the greatest dimension being in a direction from south east to north-west, forming a declination of about 22 degrees. This direction, which the meteor must have followed, is exactly that of the magnetic meridian, which is a remarkable result. The greatest of the stones fell at the south-eastern extremity of the large axis of the ellipse, the middle-sized in the centre, and the smallest at the north-western extremity. Hence it appears that the largest fell first, as might be naturally supposed. The largest of all those which fell weighed $17\frac{1}{2}$ lb. and the smallest which was subjected to M. Biot's inspection, only a thousandth part of that weight, or two French *gros*.

As we cannot make room for an analysis of M. Biot's more extended communication, we shall be contented to select only two facts.

The vicar of St. Michel declared, that he observed one of the stones fall with a hissing noise at the feet of his niece, in the court-yard of his parsonage, and that it rebounded more than a foot from the pavement. He instantly requested his niece to fetch it; but, as she was too much alarmed, a woman, who happened also to be on the spot, took it up, and it was found in every respect to resemble the others.

As one Piche, a wire-manufacturer in the village of Aunées, was working with his men in the open air, a stone grazed his arm, and fell at his feet; but it was so hot, that, on attempting to take it up, he instantly let it fall again.

He who compares the various accounts of the L'Aigle meteor with a critical eye, may, no doubt, detect some apparent contradictions, but which, on reflection, will be found strictly conformable to truth. Thus, according to some, the meteor had a rapid motion, others believed it to be stationary: some saw a very luminous ball of fire, and others only an ordinary cloud. Spectators, in fact, viewed it in different positions with regard to its direction; for they who happened to be in the line of its progress would see it stationary, for the same reason that we fancy a ship under full sail to be motionless when we are placed in its wake, or when we view it from a harbour to which it is approaching in a straight line; they, on the other hand, who had a side view of it, would reckon its motion the more rapid as their position approached to a right angle with the line of its passage, while they who saw it from behind, as the inhabitants of L'Aigle, would perceive only the cloud of vapour which it left in its train, and which, in the shade, would figure like a blazing tail, in the same manner as the smoke of a volcano appears black during the day and red at night; lastly, they who were placed in front of the meteor would reckon it stationary, but brilliant and cloudless.

It deserves to be remarked, that most of the stones, for some days after their descent, were very friable; that they gradually acquired hardness; and that, after they had lost the sulphureous odour on their surface, they still retained it in their substance, as was discovered by breaking them. Professor Sage submitted them to several comparative trials with those of Villefranche; and, although the L'Aigle specimens presented some globules of the size of a small coriander seed, of a darker grey than the mass, and not attractable by the magnet, yet, in respect of granular texture and general aspect, the coincidence was so striking as to lead one to suppose that they were all parts of the same mass. According to Fourcroy, who was also furnished with documents and specimens, most of the L'Aigle stones were irregular, polygonal, often cuboid, sometimes sub-cuneiform, and exceedingly various in their diameter and weight. They were all, he observes, covered with a black gravelly crust, consisting of a fused matter, and filled with small agglutinated grains of iron. The greater part of them were broken at the corners, either by their shock against one another, or by falling on hard bodies. The interior parts resembled those of all the meteorites analysed by Messrs. Howard and Vauquelin, being grey, somewhat varied in their shadings, granulated, and as it were scaly, split in many parts, and filled with brilliant metallic points, exactly of the same aspect as those of other stones of the like kind. Of the two specimens which M. Biot presented to Patrin, one was less compact, and of a lighter grey than the other, and exhibited, besides, small patches of a rust colour. When immersed in water, it gave a hissing sound like the humming of a fly when held by one wing. As it began to dry, it was observed to be marked by curvilinear and parallel layers. The more compact specimen, when moistened, presented no such appearances, but assumed the aspect of a grey porphyry, with a base of trap, mottled with small white spots, and speckled with metallic points.

Vauquelin's analysis of these stones yielded

Silica	53
Lime	1
Magnesia	9
Oxyd of iron	36
Nickel	3
Sulphur	2
	104

The addition of four per cent. may be attributed to the oxidation of the metals produced by the analysis. Thenard reports,

Silica	46
Magnesia	10
Oxyd of iron	45
Nickel	2
Sulphur	5
	108

M. Laugier moreover detected a small proportion of chrome. M. Lambotin and others collected specimens of this extraordinary shower of stones, and distributed them among the curious. We have seen two fine samples, one of them nearly entire, in Mr. Ferguson's collection, which we have already repeatedly quoted.

Previously to the memorable explosion above recited, no meteorites had been found in the hands of the inhabitants of this district of country, nor in the mineralogical collections of the department, nor had the slightest intimation of them occurred in the geological documents of the environs of L'Aigle. We may also note, that the forges and mines of the district in question produce nothing similar in the form of dross or ore; that the soil exhibits no traces of volcanoes; and that immediately consequent on the appearance of the meteor, a determined space of ground was strewed with stones of a peculiar character, and accompanied with circumstances which could not formerly have escaped observation. Again, nearly all the inhabitants of 20 hamlets, dispersed over the circumscribed space, declare that they were eye-witnesses of a terrible fall of stones projected from the meteor. The young, the old, and those in the prime of life, individuals of both sexes, simple peasants dwelling at a distance from one another, sagacious and rational workmen, respectable ecclesiastics, young soldiers devoid of fear, persons, in short, of various manners, professions, and opinions, and united by no common ties, all concur in attesting a fact, which contributed neither directly nor indirectly to promote their own interest; and they all assign the manifestation of this fact to the same day and the same hour. They moreover point to obvious and existing consequences of the fall of stony masses; and they aver, in terms incapable of ambiguity or misconstruction, that they really saw these masses roll down on roofs, break branches of trees, rebound from the pavement, and produce smoke when they lighted on the soil. These assertions, and their corroborative indications, refer to a portion of territory which has been accurately defined, and beyond whose precincts not a single corresponding mass has been found, nor a single individual who alleges that he saw a stone fall. Such incontrovertible evidence, then, will preclude the necessity of dilating on cases of inferior notoriety, and to which we are induced to advert, principally for the purpose of completing our chronological catalogue, and deducing the known series of an occurrence, the solution of which is still somewhat problematical.

July 4, 1803. A ball of fire struck the White Bull Inn, at East Norton, by which the chimney was thrown down, the roof partly torn off, the windows shattered to atoms, and the dairy, pantry, &c. converted into a heap of ruins. It appeared like a luminous ball of considerable magnitude, and, on coming in contact with the house, exploded with a great noise and a very oppressive sulphureous smell. Some fragments of it were found near the spot, and were subjected to chemical analysis by a gentleman in the neighbourhood, who found them to consist of one-half siliceous clay, thirty-five parts of oxidated iron, twelve of magnesia, and a small portion of nickel, with some sulphur. The surface was dark and varnished, as if in a state of fusion, and bearing numerous globules of a whitish metal, containing sulphur and nickel. From some indentures on the surface, it appeared probable that the ball was soft when it descended. Where the fragments fell, the herbage was burnt up. The meteor's motion in the air was very rapid, and apparently parallel to the horizon. *Liter. Journal.*

October 5, 1803. Stones fell near Avignon. *Bibl. Britan.*

December 13, 1803. The inhabitants of the village of St. Nicholas, in Bavaria, were alarmed between eleven and twelve o'clock, noon, by a noise which resembled the report of several cannons. A peasant, who went out of his house to see what was the matter, observed the sky to become dark and gloomy, heard a singular hissing in the air, and perceived something fall on a barn with a loud noise. On entering the barn, he found a stone which had broken the rafters by its fall, was still warm, smelled of sulphur, and weighed three pounds and a quarter. It was covered by a thin, blackish, and apparently bituminous incrustation. Its substance was of an ash-grey colour, earthy, and resembling hardened clay, but without odour. It was found to contain small shining particles of native iron, small bright grains of martial pyrites, which yielded a black powder when pounded, hard and very bright flattened masses, of a black and dark-brown hue, some minute grains of a cubical form, and small yellowish transparent laminæ, with glass glance, having the appearance, but not the hardness, of quartz. Yellowish, white, and metallic points, probably native nickel, were discovered by the microscope. The chemical analysis of 10,000 grains of this specimen, gave

Iron, in the metallic state,	1800
Brown oxyd of do.	2540
Regulus of nickel,	1350
Magnesia,	3250
Silex,	1000
Supposed sulphur,	60
	10,000

Journal de Physique, Gilb. An. Voight's Mag.

April 5, 1804. Three men at work in a field at Possil, about three miles north from Glasgow, were alarmed by a singular noise, which seemed to proceed from the south-east to the north-west, and continued, as they supposed, for about two minutes. They compared it, at first, to four discharges of cannon, afterwards to the sound of a bell, or rather of a gong, with a violently whizzing noise; and, lastly, they heard a sound, as if some hard body very forcibly struck the surface of the earth. At the same time, sixteen men who were at work in the Possil stone quarry, thirty feet under the surface of the soil, heard a noise like the discharge of artillery, and then like the sound of hard substances hurling downwards over stones, and lasting, in the whole, for about the space of a minute. The overseer of the quarry, and a man who was on a tree, described the noise as if continuing about two minutes, apparently beginning in the west, and passing round by the south, towards the east, at first like the firing of three or four cannons, at the distance of a mile and a half to the west of the quarry, and terminating in a violent rushing, or whizzing. Along with these persons, there were two boys, one of ten, and the other of four years of age, and a dog, which, on hearing the noise, ran home, seemingly in great terror. The overseer, too, was considerably alarmed by a misty commotion which he observed in the atmosphere. "Come down," exclaimed he, to the man on the tree, "I think there is some judgment coming upon us." The man had scarcely got on the ground, when something struck, with great force, in a drain, at the distance of about ninety yards, splashing mud and water for twenty feet round. The elder boy observed the appearance of smoke in the air, and something of a reddish colour, moving rapidly from the west, till it fell on the ground. A moment before the stroke on the earth was heard, the younger boy called out—"*Oh! sik a reek!*" (such a smoke,) alluding to the smoke which he saw near the place where the body fell on the ground. On running up to this spot, the overseer observed a hole in the bottom of the drain, which was filling with water, about six inches of it remaining still empty. At the bottom of this hole he felt something hard, which he could not move with his hand. The operation of the shovel and mattock revealed two pieces of stone, which had penetrated a few inches into the soft sandy rock, and eighteen inches below the bottom of the drain, the hole being about fifteen inches in diameter. He was not sensible of any particular heat in the water, or in the pieces of stone, nor of any uncommon smell in the latter, although he applied them to his nostrils. One of the pieces was about two inches long, the other about six inches long, four broad, and four thick, and blunted at the edges and end. The fractures of the two pieces exactly coincided; but he could not say whether their separation had been effected by the violence of the fall, or a stroke of the mattock. As he conceived them to be merely pieces of whinstone, they were, at first, neglected; but a careful search being made for them, some days after, the smallest fragment was soon found. The largest, however, having been used as a block in the quarry, and having fallen among rubbish, could not be discovered; but a fragment of it was found some days after The two recovered morsels, one of which is deposited in the Hunterian museum, in the university of Glasgow, formed the two extremes of the stone, and are characterized by the smooth black external coating, and the internal greyish aspect. The late Robert Crawfurd of Possil, Esq. and several of the professors of the university of Glasgow, were at pains to ascertain the preceding circumstances. Mr. Crawfurd remarked, that both the fragments had a fishy, fetid smell, when he first received them. The day on which the phenomenon took place was cold and cloudy; and the noise of the explosion was heard as far as Falkirk, which is about twenty-four miles to the east of Glasgow.

1804, or 1807. A stone fell near Dordrecht. *Van Beck-Calkoen.*

October 6, 1804. A violent explosion was heard, near Apt, in the department of Vaucluse, and for fifteen leagues round, accompanied by an extraordinary hissing, and the fall of a stone of about seven pounds weight. It was presented, by the minister of the interior, to the National Institute; and Vauquelin, who alludes to it in No. 144 of the *Annales de Chimie*, asserts, that all its physical characters, and the details of the judicial report concerning it, are in perfect unison with our present state of knowledge on the subject. It is, however, worthy of remark, that the detonation was preceded by no luminous meteor. Laugier reports, as the results of the chemical analysis of the stone,

Silica,	34
Magnesia,	14.5
Iron,	38.03
Nickel,	0.33
Manganese,	0.83
Sulphur,	9.
	96 69.

March 25, 1805. Stones fell near Doroninsk, at no great distance from the river Indoga, in the government of Irkutsch, in Siberia. *Gilb. An.*

June, 1805. Haïr Kougas Ingigian, author of a work, entitled *Eghang-Buzankian*, printed at Venice, in 1807, makes mention of several stones having fallen in one of the public squares of Constantinople, called *Etmeydany*. Haïr Mesrob Vartabete, an Armenian, conversant in chemistry, mineralogy, and in the physical and mathematical sciences in general, translated the passage which gives an account of this event, into French, for the perusal of M. Tonnelier; and the latter, in the Journal of Mines for February, 1808, briefly states, that the descent of the stones took place in broad day, and with great violence; that the people believed it to be the work of evil spirits; that the agents of police verified the fact; and that a guard of Janissaries was stationed on the spot, for three successive days and nights. The smell of sulphur which accompanied the fall, and the black and scorched crust of the pieces collected, scarcely permit us to doubt that they were genuine meteorites.

March 15, 1806. In the *Journal de Physique*, for June 1806, there is a short account of the fall of two *aërolites*, (for so they are termed in the report,) by Dr. Pages and M. Dhombres-Firmas, both members of the Academy of Ghent. The particulars are nearly as follow:—

At half-past five o'clock in the evening, the inhabitants of Alais, and the neighbouring parishes, heard two loud explosions, between which only a few seconds intervened, and which were both supposed to be the discharge of cannon. The rolling noise which succeeded, lasted ten or twelve minutes. Some drops of rain had fallen in the morning; the sky was clear at mid-day; but clouds occasionally obscured the sun in the afternoon, when the centigrade thermometer indicated a maximum of + 12.5. The heavens became more cloudy and dark after the detonations. The Sieurs Penarier, father and son, who were in the fields adjoining to the village of St. Etienne de L'Olm, about twelve kilometers from Alais, heard the two explosions, which were not preceded by lightning, and which they at first supposed to be the firing of cannon at St. Hippolyte-le-fort; but the rolling sound which succeeded, and which seemed to them to describe a curve in the heavens, from west to south, and from south to east, quickly undeceived them. As they looked more attentively at the clouds, an extraordinary hissing noise succeeded the rolling, and they distinctly perceived a blackish body proceeding from the clouds, obliquely advancing towards them from the north, and which, after passing over their heads, fell in a corn-field below the village, and broke in shivers, with a considerable noise. Accompanied by several of the alarmed villagers, they immediately went in quest of it, and found that it had pierced the soil, and broken into dispersed fragments against a rocky stratum, only small splinters, which were diluted by the rain that fell two days after, remaining in the hollow formed by the falling mass. From the respective weights of the fragments, it was supposed that that of the entire stone might be 4000 grammes. Its form, so far as could be inferred from the fragments, was irregular and angular; and it was black *internally* as well as on the surface, which last seemed to have undergone the action of fire.

There fell, at the same time, at Valence, a village near Alais, another stone, of a rudely cubical form, of the size of a child's head, and about four pounds weight. The persons who witnessed its descent, were Pierre Reboul, and son, Vincent Mazel, and Pierre Esperaudieu, servant to the mayor of Valence, who were labouring in the fields when the explosions and rolling noise mentioned above arrested their attention. According to their report, these noises were followed by another, resembling that of an iron pulley, by means of which a bucket is rapidly let down into a draw-well. On looking up, they perceived a black body moving from the north, in an oblique direction, which fell among them, about fifteen paces from Reboul. They all ran to the spot, and found it half buried in the earth, still hot, and split into three parts, which were again divided, as each was desirous of having a specimen.

The Alais stone, according to Thénard, had such a strong resemblance to coal, that they who found it attempted to burn it. Its specific gravity was 1940, consequently very inferior to that of other meteorites whose specific gravity has been ascertained. Its internal substance exhibited some yellow specks of martial pyrites, and a great many cubical points, slightly united to one another, and so friable that the least pressure reduced them to fragments of the size of grains of sand. It was destitute of savour, and insoluble in water. When heated in the open air, its black hue passed to a reddish yellow; but, when heated in close vessels, remained unchanged. Before the common blow-pipe, it was infusible, without addition; but, when mixed with borax, it readily melted, and communicated to that salt a greenish-yellow tinge. The same ingenious chemist states it component parts to be,

Silica,	21
Magnesia,	9
Oxyd of iron,	40
Nickel,	2.50
Manganese,	2
Sulphur,	3.5
Chrome,	1
Carbon,	2.5,

the remainder being estimated as water. Vauquelin again reports,

Silica,	30
Magnesia,	11
Iron,	38
Nickel,	2
Manganese,	2
Sulphur,	1
Chrome,	2.5
Carbon, a trace.	

and the virtual import of these analyses was attested by Monge, Fourcroy, and Berthollet.

May 17, 1806. As Mr. William Paice, of Basingstoke, Hants, was travelling with his cart, a few miles from home, he met a person, who inquired of him whether he had seen a stream of fire descend from the air, like a falling star, there having been some thunder just before. Mr. Paice had not observed it; but, going on a little farther, he found a large ball, or stone, which he took up, while yet hot, from the middle of the road, threw it into his cart, and brought it home. It had a metallic appearance, and weighed two pounds and a half. *Month. Mag.*

March 13, 1807. In the afternoon, the inhabitants of the Canton of Juchnow, in the government of Smolensko, were alarmed by an uncommonly loud noise, which they supposed to be thunder; and two peasants being out in the fields, perceived, at the distance of forty paces, a black stone, of considerable magnitude, falling to the earth, which it penetrated to a considerable depth beneath the snow. When dug up, it was found to be of an oblong quadrangular figure, of a blackish colour, resembling cast iron, and to weigh 160 pounds

A fragment of this mass is preserved in the imperial cabinet of Vienna. Its specific gravity was 3.7; and Klaproth notes its constituents thus,

Silica, ...	38
Alumina, . . .	1
Lime, ...	0.75
Magnesia, . . .	14.25
Oxyd of iron, . . .	25
Regulus of do. . .	17.60
Nickel, ...	0.40
Manganese, } a trace.	
Sulphur, }	
	97

December 14, 1807. About half past six o'clock in the morning, the people to the north of Weston, in Connecticut, North America observed a fire-ball issuing from a very dark cloud. Its apparent diameter was equal to that of the half, or of two-thirds, of the moon; its light was vivid and sparkling, like that of incandescent iron, and it left behind it a pale and waving luminous train, of a conical form, and ten or twelve times as long as the diameter of its body, but which was soon extinguished. This meteor, of which the apparent motion was less rapid than that of most others, continued visible for half a minute, during which it exhibited three successive bounds, with a diminution of its lustre. About thirty or forty seconds after its extinction, there were heard, during three seconds, three very loud reports, like the firing of a four pounder at a little distance; and these were succeeded by a more prolonged and rolling noise. With the successive explosions, stones were darted in the environs of Weston, and even into the town itself. These stones were found in six different places, nearly in the line of the meteor's path, and from six to ten miles distant from one another. They fell in the presence of many witnesses, some plunging into soft soil, and others breaking into fragments against the rocks on which they happened to impinge. The most entire specimen weighed 35 lb., but a much larger was dashed in pieces against a rock of mica-slate; and, from the amount of fragments collected, it was estimated to have weighed 200 lb. At the moment of their fall, these stones were hot and friable; but they gradually became hard by exposure to the air. They had the black external crust of other meteorites, and the usual grey cinereous aspect within, with whitish-grey particles, of a rounded form, impacted in the mass, and a general granular texture, in which were observable, 1. Globules of the same nature with the stone, but presenting a more compact structure, a more even fracture, and, under a strong light, indications of a lamellar texture, with the appearance of felspar; 2. Grains of very white metallic iron; 3. Grains of oxyd of iron, of rust colour; and, 4. Shining yellow sulphuret of iron, disseminated in very minute grains. Their specific gravity varied from 3.3 to 3.6, and their analysis, as reported by Warden, yielded,

Silica, ...	41
Alumina, . . .	1
Lime, ...	3
Magnesia, . . .	16
Oxyd of iron, . . .	30
Manganese, . . .	1.34
Sulphur, . . .	2.33
Chrome, . . .	2.33
	97

Such is a mere outline of the principal circumstances relative to the Weston phenomenon, for the more ample details of which we must refer our readers to an interesting memoir, inserted in the Medical Repository for 1807, the joint production of Messrs Silliman and Kingsley, and to another by Mr. Bowditch, published in the third volume of the American Academy of Arts and Sciences, and reprinted in the 28th volume of Nicholson's Journal.

March 5 and 6, 1808. A shower of red snow fell, during three nights, in Carniola, and over the whole surface of Carnia, Cadore, Belluno, and Feltri, to the height of five feet ten inches. The earth was previously covered with snow of a pure white, and the coloured variety was again succeeded by the common sort, the two kinds remaining perfectly distinct, even during liquefaction. When a portion of the red was melted, and the water evaporated, a little finely divided earth, of a rose hue, remained not attractable by the magnet, and consisting of silex, alumine, and oxyd of iron. The same phenomenon was observed at the same time, on the mountains of the Valteline, Brescia, and the Tyrol.

April 19, 1808. At one o'clock P. M. stones fell at Borgo San Domino, near Pieve di Cassignano, in the department of Taro, and in the neighbourhood of Parma and Placenza. Guidotti, who analyzed a specimen, found it to consist of,

Silica, . . .	50
Magnesia, . . .	11
Oxyd of iron, . .	39
Nickel, ...	2 50
Sulphur, . . .	4
	106.50

A specimen of this shower is preserved in the Vienna cabinet, a repository rich in the number of samples of this description of stones.

May 22, 1808. At six o'clock in the morning, a shower of stones occurred at Stannern, near Iglau, in Moravia, attended with the usual circumstances. These stones are described as of a whitish or bluish-grey, tender, friable, not magnetic, speckled with black points, containing very few visible metallic particles, except some prominent grains, not attractable by the magnet, and probably pyritical. The exterior crust resembled a black, or brown varnish, very glossy and vitreous, having the surface marked by minute folds or wrinkles. Their specific gravity was 3.19; and the result of their analysis by Vauquelin,

Silica, ...	50
Alumina, ...	9
Lime, ...	12
Iron, ...	29
Nickel, a trace	
Manganese, . . .	1
Sulphur, a trace	
	101

Moser's report includes 2.5 of magnesia.

September 3, 1808. M. Reuss, counsellor of mines, has published a Memoir on the meteorites which fell, at half past three o'clock in the afternoon, near Lissa, in Bohemia: and from this document we have selected the following most material circumstances.

Four days after the event, the mayor of the district received an official report on the subject, as did afterwards M. Merkl, counsellor of the government, who communicated the contents to the Chancery. Lissa is a small town, situated four miles west north-west from Prague; and the district in which the stones fell is a plain, which extends southwards to the banks of the Elbe. The soil, in general, is a dry meagre sand, fit only for the culture of rye, and the rocks which it comprizes are of a ferruginous argillaceous sandstone. The field on which the meteorites alighted had been recently ploughed, and had for its basis a very open, sandy earth, into which, nevertheless, one of the stones sunk only to the depth of four inches. Another, which fell on an adjoining field, of a somewhat more compact and argillaceous texture, penetrated four or five inches. A third fell in a small pine forest, on a sandy soil, covered here and there with green turf, and left, in like manner, a mark of four or five inches deep. Though all its angles were more or less fractured, it weighed five pounds nine ounces and a half. The most intelligent people in the neighbourhood declared that they heard a violent detonation, like the discharge of many pieces of ordnance, followed by a noise like platoon firing, or a prolonged beating of drums, which lasted for twenty or twenty five minutes. The sky, which had been perfectly clear, became covered as with a thin gauze, through which the sun's rays easily penetrated; but nobody perceived lightning, nor any luminous meteor, nor felt any of that oppressive uneasiness, which frequently indicates an electrified atmosphere. Of the four masses which were collected, the actual descent of none through the air appears to have been distinctly witnessed; but some reapers, who took up one of them, at the moment that it struck the ground, felt it as cold as the surrounding stones; and none of them stained the fingers, or emitted any sulphureous odour. In other respects, they bore a manifest resemblance to many of those which we have described, being composed of mixed ingredients, of a pale cinereous grey colour, and granular texture, traversed in every direction by small veins and speckled with minute, disseminated globules. Their specific gravity is stated at 3.56, and Claproth found them to contain,

Silica,	43
Alumina,	1.25
Lime,	0.50
Magnesia	22
Iron,	29
Nickel,	0 50
Manganese,	0.25
Sulphur, a trace	
	96.50

All the iron contained in the specimen submitted to trial, appeared to be in the metallic state. The peculiarities attending this case are, detonation without any luminous meteor, the very moderate impetus of the falling bodies, and their want of sensible heat.

July 17, 1809. A stone, weighing six ounces, fell on board an American vessel, in Lat. 3 ° 65′ N. and Long. 70°,25′. W. *Medic. Repos. Biblioth. Britan.*

January 30, 1810. At two o'clock, P. M. a fall of meteorites occurred in Caswell county, North America. Their descent was visible for a considerable distance round; and two reports were distinctly heard at Hillsborough, thirty miles from the spot where the fall took place. One of the fragments, weighing a pound and three quarters, struck a tree near the place where some woodcutters were at work, but who ran home, without ever once looking behind them. Encouraged, however, by a woman, whose curiosity was superior to her fears, they returned with her, and found the stone, which was still hot. It is vaguely said to have been of a dark-brown colour, and porous. *Phil. Mag.* vol. xxxvi.

July, 1810. A letter from Futty-Ghur, in the East Indies, dated July 21st, presents us with the following imperfect, but curious, account of the phenomenon which we have been considering. "I open this letter to let you know of a very odd circumstance which happened a few days ago. viz.—A large ball of fire fell from the clouds, which has burned five villages, destroyed the crops, and some men and women. This happened near Shahabad, across the Ganges, about 30 miles northward from this place. I have heard nothing further about this but a vague report."

August 10, 1810. In this stage of our historical record, it will be proper to insert the ensuing letter from Maurice Crosbie Moore, Esq. to William Higgins, Esq.

"Sir.—I had the honour of receiving a letter, requesting from me the particulars respecting a meteoric stone that fell near my house, in the county of Tipperary, and which a short time ago I did myself the pleasure of presenting to the Dublin Society. The particulars are as follow:—Early last August, between eleven and twelve o'clock in the morning, I went from Moore's Fort to Limerick; the day was dark and sultry. I returned in a few days, and was immediately informed by my steward and butler, that a most wonderful phenomenon had occurred very soon after my departure; they produced the stone, and gave the following account of the occurrence:—There had been thunder; some workmen, who were laying lead along the gutters of my house, were suddenly astonished at hearing a whistling noise in the air; one said, 'The chimney is on fire;' another said, 'It proceeds from a swarm of bees in the air.' On looking up, they observed a small black cloud, very low, carried by a different current of air from the mass of clouds, from whence they imagined this stone to have proceeded; it flew with the greatest velocity over their heads, and fell in a field, about three hundred yards from the house: they saw it fall. It was immediately dug up, and taken into the steward's office, where it remained two hours cooling before it could be handled. This account I have had from many who were present, and agree in the one story. I saw, myself, the hole the stone made in the ground; it was not more than a foot in depth," &c.

This stone was not injured by the fall, and was of a somewhat cubical shape with the angles and edges of two sides rounded; the other two opposite sides exhibited a very uneven surface, occasioned by depressions and prominences, as if a part had been broken previous to the heat to which it must have been exposed before its fall. It weighed seven pounds and three quarters; and the entire surface was covered with a brownish-black thin crust, evidently the effect of fusion, by an intense and rapid heat. On inspection of its internal texture, there were distinguishable, 1. Dark-grey particles of malleable iron, without any regular shape, of unequal magnitude, numerously dispersed, and rendered bright when rubbed with a file; 2. Some very small bright particles of iron; 3. Particles of martial pyrites, of various colours, some being reddish-yellow, some yellowish-white, and a very few of a purplish tinge; 4. A very few round globules, about the size of mustard-seed, of a greyish-brown, readily yielding to the file, and seeming to contain no metallic matter. These several materials are cemented by a whitish-grey earthy substance, while minute yellowish-brown spots, very close to one another, and proceeding from oxyd of iron, are disseminated in the mass. According to Mr. Higgins, its specific gravity is 3670; and its analysis gave, in one instance,

Silica	48.25
Magnesia	9
Iron	39
Nickel	1.75
Sulphur	4
	102

and, in another,

Silica	46
Magnesia	12.25
Iron	42
Nickel	1.50
Sulphur	4
	105.75

the excess being attributable to the absorption of oxygen by the metallic bodies.

November 23, 1810. At half after one o'clock P. M. three stones fell in the commune of Charsonville, in the department of the Loiret, and neighbourhood of Orleans. Their fall was accompanied by a series of detonations which lasted some minutes, and which, along with the reverberations from the echoes, were heard as loud at Orleans, Montargis, Salbri, Vierzon, and Blois, as at the place where the stones fell, exciting alarm from the apprehension of the blowing up of a powder magazine. These stones were precipitated perpendicularly, and without the appearance of any light or ball of fire. One of them took the ground at Montelle, but was never discovered; and, of the other two, one fell at Villenoi, and the other at Moulin-Brûle, all which places are within the distance of a mile. One of the stones weighed about twenty pounds, and made a hole in the ground just large enough for its admission, in a perpendicular direction, driving up the earth to the height of eight or ten feet. It was taken out half an hour after, when it was still so hot that it could scarcely be held in the hand; and it had a strong smell of gunpowder, which it retained till it was quite cold. The second formed a similar hole, three feet deep, weighed forty pounds, and lay fourteen hours in the ground before it was extracted, when it was quite cool.

Both these stones were shapeless masses, irregularly rounded at the projections, contained rather more ferruginous globules than those of L'Aigle, and presented a lighter colour, when broken. They were quickly oxydated, very heavy, sufficiently hard to scratch glass, of difficult frangibility, and characterized by an irregular and very fine-grained fracture. The external crust was the fourth part of a line in thickness, and of a blackish-grey colour, while the internal substance was traversed by black lines, or veins, in all directions. The specific gravity of these stones is mentioned, as varying from 3.6 to 3.7; and the specimen analyzed by Vauquelin, afforded to that eminent chemist,

Silica,	38.4
Alumine,	3.6
Lime,	4.2
Magnesia,	13.6
Iron,	25.8
Nickel,	6
Manganese,	0.6
Sulphur,	5
Chrome,	1.5
	98.7

The day on which these stones fell was remarkably calm and serene, the sun shone as bright as in one of the finest days of autumn, and not a cloud appeared above the horizon.

March 12, 1811. A meteorite of the weight of fifteen pounds, fell to the earth, in the village of Thonleghorosk, dependant on the town of Romea, in the government of Tschernigoff, in Russia. Its fall was preceded by three loud peals, like thunder. When dug from the depth of more than three feet, in a thick layer of ice, it was still hot. It was remarked, that, at the third detonation, there was an extraordinary explosion, accompanied with a loud hissing noise, and the diffusion of a great quantity of sparks. *Gilb. An.*

July 8, 1811. Stones, one of which weighed three ounces and a quarter, fell at Ballinguillas, in Spain. *Biblioth. Britan. T.* 48.

April 10, 1812. According to the report of D'Aubuisson, chief engineer of mines, about eight o'clock in the evening, a brilliant light was seen in the atmosphere at Toulouse, and for several leagues around. The people at first supposed that the powder magazine of Toulouse had been blown up; and when it was discovered that this was unfounded, the light and noise were ascribed to some extraordinary meteor; for the cold state of the atmosphere, and the force of the explosion, did not admit the idea of its being a simple peal of thunder. A few days afterwards, it was ascertained, that this phenomenon had been accompanied by a shower of stones, at two leagues W. N. W. of Grenade, in the communes of Burgave, Camville, and Verdun, situated in the departments of the Upper Garonne, and of the Tarn and Garonne. As some specimens were sent to the prefect of the Upper Garonne, that magistrate appointed a committee, composed of M. D'Aubuisson, M. Saget, of the Academy of Sciences, Marqué-Victor, professor of physics, and Carney, professor of mathematics, to proceed to the spot, and collect the details of the phenomenon.

The light which spread over the atmosphere burst forth all at once. Although the sun had set an hour and a half before, and the air was dark, the light was so brilliant, that the mayor of Grenade said he could read the smallest characters, and the mayor of Camville compared it to the light of the sun, adding, that the town-clock was as visible as at noon-day, and that a pin might have been picked up from the streets. The exact duration of this light was not remarked, some persons reckoning it at two minutes; others at one; and others at still less: but scarcely had it disappeared in the place where the meteorites fell, when there were heard in the air three violent detonations, similar to the report of large pieces of cannon, succeeding one another, with hardly any interval, and heard at Castres, twenty leagues from the spot where the stones fell. They were followed by a very loud noise, which some compared to that of heavy carriages rolling at once on the pavement; others compared it to the sound of several drums; and others to a strong fire of musquetry, from the Spaniards having invaded the country. This rolling noise seemed to issue from the N. E. and to proceed to the S. E.; and, after it had passed over the ground situated between the farms of la Bordette and La Pradère, a sharp hissing noise was heard, which ended in considerable shocks, similar to grape-shot striking the ground, and produced by the fall of the meteorites.

"I now," says M. D'Aubuisson, "give the information received, as to the Aërolites which were collected, or heard to fall.

"1. The inhabitants of the little farm called la Bordette, distinctly heard two aërolites fall; one to the northward, in a field adjoining, which they have not yet found: the other was found about fifty paces to the south-east: the fragment which we have weighs three ounces, and the whole stone did not weigh six.

"2. At the cottage called Paris, (300 metres above Pemejan) the inhabitants were at the door, listening to the rolling noise over their heads, when they heard the noise of a body which fell in front of them. The master of the house then went back through the house, to shut the door of a stable, and, when there, he heard a second large body fall. The interval between the two must have been about seventy-five seconds. This fact is of importance.

"3. At Pemejan, the inhabitants, equally alarmed at a stone which fell near them, took refuge in the house, when they heard a second hissing sound, followed by the noise of a body falling on the roof. Next day they found a tile broken, and a stone, weighing about three ounces, resting on the lath. Having carefully examined this spot, I found no contusion, nor any mark of fire on the wood of the roof. In the vicinity of the farm, two stones were found, which weighed only a few ounces.

"4. At Richard, after the rolling noise, an explosion was heard in the air, and next day a stone, weighing eight ounces, was found.

"5 At Pradère there fell, about one pace from the house, with considerable noise, and more than a minute after the detonations, an aerolite, weighing two pounds. It was not entirely sunk in the earth, and was not perceived until two days afterwards. A few seconds afterwards a smaller stone fell, forty paces in front of the house"

The quantity of meteorites that fell on this occasion probably much exceeded the small number collected; for the ground was partly in grass, and partly ploughed up; and the event took place when most of the inhabitants were in bed. The description of these stones so nearly accords with that of several others already specified, that it would be superfluous to note their aspect and properties.

April 15. 1812. A stone, of the size of a child's head, fell at Erxleben; and a specimen of it is in the possession of Professor Haussmann, of Brunswick. *Gilb. An.* T. 40. and 41.

August 5, 1812. Several stones, one of which weighed 65 lb., fell at Chantonnay, eight leagues north-west from Fontenay, in the department of La Vendée. Their structure is nearly analogous to that of the Barbotan specimens; but they contain such a large proportion of iron in the metallic state, that they are susceptible of a brilliant polish, and of bearing the graving tool.

March 14, 1813. A very remarkable phenomenon occured at the town of Gerace, in Calabria, and is described by Professor Sementini of Naples. The wind was westerly, and heavy clouds were approaching the land, over the sea. About two o'clock, P. M. the wind fell, and the sky became quite dark. The clouds then assumed a red and threatening appearance; thunder followed; and there fell red rain and snow, mingled with red dust. The alarmed inhabitants, conceiving that the end of the world was at hand, flocked to the churches. The red dust was very fine, became black when exposed to a red heat, and effervesced, when treated with acids. Its constituents were silica, carbonate of lime, alumine, iron, and chrome. What renders this precipitation the more remarkable is, that its ingredients are nearly the same with those of one of the varieties of meteorites; and hence they probably have a similar origin. According to Chladni and others, stones were observed to accompany the dust; and, if so, the intimate connection of the two appearances can no longer be reasonably questioned. Sementini's analysis of the red powder gave.

Silex, ...	33
Alumine, . . .	$15\frac{1}{2}$
Lime, ...	$11\frac{1}{2}$
Iron, ...	$14\frac{1}{2}$
Chrome, . . .	1
Carbon, . . .	9
	$84\frac{1}{2}$

Should the defect afterwards be found to consist of nickel and magnesia, we might then with safety maintain their identity.

On the present occasion, the coloured rain and snow seem to have fallen over a great extent of country; for red rain fell in the two Calabrias, and on the opposite side of Abruzzo, the wind being at east and south-east. Snow and hail, of a yellow-red colour, fell over all Tuscany, with a north wind. Red snow fell at Tolmezzo, and in the Carnian Alps, the wind being at north-east; and, finally, snow of a brownish-yellow fell at Bologna, the wind being south-west.

September 10, 1813. Samuel Maxwell, Esq. a gentleman of the highest respectability, and an ocular witness of the scene which he describes, communicates, in substance, the ensuing particulars to William Higgins, Esq. of the Dublin Society.

Friday morning being very calm and serene, and the sky being clear, about nine o'clock, a cloud appeared in the east, from which proceeded eleven distinct reports, somewhat resembling the discharge of heavy artillery. These were immediately followed by a considerable noise, not unlike the beating of a large drum, which was succeeded by an uproar, resembling the continuous discharge of musketry in line. The sky above the place whence the noise seemed to issue, became dark and agitated, emitting a hissing noise, and projected with great violence, different masses of matter, which shaped their course, with great velocity, in a horizontal direction towards the west. One of them, which was observed to descend, fell to the earth, and sunk into it more than a foot and a half, on the lands of Scagh, in the neighbourhood of Pobuck's Well, in the county of Limerick. Being immediately dug out, it felt hot, and had a sulphureous smell, with the whole of its surface uniformly smooth and black, the entire mass weighing 17 lb. Six or seven more, but smaller and fractured, alighted at the same time with great force, in different places, between the lands of Scagh and the village of Adare. Another very large mass passed with great rapidity, and a considerable noise, at no great distance from Mr. Maxwell, came to the ground on the lands of Brasky, and penetrated through a very hard and dry earth, to the depth of two feet. This last was not taken up for two days, when it was found to weigh about 65 lb. and to be fractured in many places. Another, weighing above 24 lb. and very heavy for its bulk, but exhibiting no symptoms of fracture, fell on the lands of Faha.

"There was no flash of lightning at the time of, or immediately before or after the explosion; the day continued very calm and serene; was rather close and sultry, and without wind or rain. It is about three miles in a direct line from the lands of Brasky, where the very large stone descended to the place where the small one fell in Adare, and all the others fell immediately; but they appeared to descend horizontally, and as if discharged from a bomb, and scattered in the air."

February 3, 1814. Stones fell in Bachmut, in Russia. *Gilb. An.* T. 50. Giese, who analysed a specimen, reports,

Silica, . . .	44
Alumine, . .	3
Magnesia, . .	18
Iron, . . .	21
Nickel, . .	2.50
Manganese . .	1
Sulphur, . . .	.50
Chrome, . . .	.50
	90.50

September 5, 1814. In the 92d volume of the *Annales de Chimie*, M. de Saint-Amans relates the following circumstance of what he terms, not improperly, *uranolites*, near Agen.

A few minutes before mid-day, the wind being northerly, and the sky perfectly serene, a violent detonation was heard in the communes of Montpezat, Temple, Castelmoron, and Montelar, situated in the first, second, and fourth *arrondissemens* of the department of the Lot and Garonne. This unusual detonation was immediately followed by three or four others, at an interval of half a second, successively; and finally, by a rolling noise, at first resembling a discharge of musketry, afterwards the rumbling of carriages, and, lastly, that of a large building falling down. These strange noises, which proceeded from the centre of the department, were more or less audible within a circle of several leagues. The resemblance and volume of the stones which were precipitated to the ground, on the cessation of the explosions, appear to have been considerable. Some were sent to the prefect, who transmitted them to the minister of the interior, others were distributed among the curious, while many were picked up by the peasants, and venerated as reliques. Two are mentioned as weighing eighteen pounds each. It should seem that they were not found warm at the moment of their fall; that the heaviest sunk into a compact soil to the depth of eight or nine inches, and that one of them rebounded three or four feet from the ground. It is added, that they fell obliquely, making an angle of from 65 to 70 degrees with the horizontal line, and that they diverged in their fall, affecting various directions in the different communes in which they fell. "All the specimens of these stones which I saw," observes the reporter, "present no character to the eye which can make them be distinguished from those which I have hitherto had occasion to examine, or which I have in my cabinet: they merely seemed to be more friable and more porous than the latter." His account of the white cloud, too, which accompanied the meteor, corresponds with those of such as have more than once been observed to attend similar appearances.

July 3, 1814. A great shower of ashes in the river St. Lawrence. *Phil. Mag.*

November 5, 1814. "A singular phenomenon," says a native philosopher of the spot, "has occurred in the Doab. I have heard the facts related by various persons, who all concur in the same account. The circumstances are as follow: On the 5th of November, being Saturday, while half a watch of the day still remained, (*i. e.* half past four o'clock, P. M.) there was first of all heard a dreadful peal of thunder, and then stones rained down in sight of the inhabitants of the country, each stone being 13 or 15 seer* in weight. In the first place, wheresoever they fell a great dust rose from the ground; and, after the dust subsided, a heap of dust was formed, and in that dust were found the stones, a piece of one of which is sent herewith.

"In the district of Lapk seven stones were found; in the district of Bahweri, dependant on Bezum Sumroo, four; in the district of Chal, belonging to the pergunnah of Shawlif, five; at Kabout, belonging to the pergunnah of Shawlif, five. In all nineteen stones were found." *Phil. Mag. Biblioth. Britan.*

About the end of September, 1815, the south Sea was covered to a great extent with dust, supposed to have proceeded from the fall of a meteor. *Phil. Mag.*

October 3, 1815. At half-past eight o'clock, in the morning, the sky being clear and serene, with a gentle easterly wind, there was heard a rumbling noise like the discharge of musketry and artillery. This noise, which apparently proceeded from the north-east, and from a grey cloud of an indeterminate form, which hung over the horizon, had lasted a few minutes, when a man at work in a vineyard, at some distance from Chassigny, a village situated about four leagues to the south-east of Langres, and who had his eye fixed on the cloud, hearing a whistling like that of a cannon ball, saw an opaque body fall at a few paces from him, and which emitted a dense smoke. On running to the spot, he perceived a deep hole in the ground, with fragments of a peculiar sort of stone scattered around it. Having picked up one of the pieces, he found it as hot as if it had been long exposed to the ardent rays of the sun. In consequence of his having brought it into the village, several of the inhabitants went out and collected specimens. Next day Dr. Pistollet, physician at Langres, visited Chassigny, and having obtained one of the fragments, was struck with its resemblance to a meteorite which had been sent to him from Germany. He was, there-

* "The Bengal seer weighs 2 lb. and 2 drams."

fore, induced to repair to the spot, and collected about sixty small pieces, some of which were soft and wet, and easily crumbled in the hand; but all seemed to have belonged to one mass. In some of them the external crust was of a deep black, and in others of a glossy chesnut-brown. On the blackest crusts elevations or swellings were observed, like the produce of ebullition suddenly arrested. Internally, these specimens were grey-white, with a light greenish tint, granular, sufficiently soft to be scratched with a knife, composed of small brilliant and raised crystalline laminæ, and of a multitude of minute black ferruginous points, heavy, not magnetic, and interspersed with distant small round pores.

In this instance, Vauquelin's analysis afforded,

Silica	33.90
Oxidated iron	31
Magnesia	82
Chrome	2
	98.90

The Chassigny stones, therefore, are remarkable for their crystalline texture, for their want of nickel and sulphur, and for their more than ordinary proportions of magnesia and chrome.

April 15, 1816. Coloured snow again fell in Italy, particularly on Tonal and other mountains. It was of a brick red, and left an earthy powder very light and impalpable, unctuous to the touch, of an argillaceous odour, and sub-acid, saline, and astringent taste. Twenty-six grains, when analysed, gave the following results:

Silex	8
Iron	5
Alumine	3
Lime	1
Carbonic acid	.5
Sulphur	.25
Empyreumatic oil	2
Carbon	2
Water	2
Loss	2 25
	26

1806. A stone fell at Glastonbury, in Somersetshire. *Phil. Mag.*

May 2 and 3, 1817. There is reason to believe that masses of stone fell into the Baltic, because, after the great meteor of Gottenburgh, a stream of fire was observed from Odensee to descend rapidly into the sea, in the south-east. *Chladni.*

November 3, 1817. According to the French newspapers, a meteor of considerable size fell, in the morning, in the Rue de Richelieu, Paris, descending with so much force as to displace a part of the pavement, and to sink to some depth in the earth. It was accompanied by a sulphureous smell, and seemed to have been recently in a state of ignition or combustion. If such an incident really took place, it is to be hoped that some more distinct memorial of the particulars, and the exhibition of the stone itself, will not be withholden from the public.

In regard to the alleged fall of a great stone at Limoges, on February 15. 1818, and which Chladni probably copied from the public prints, the report seems to have been premature. See the new edition of *Nouveau Dictionnaire d'Histoire Naturelle*, t. 26, p. 270, in the margin.

July 29, O. S. 1818. A stone of seven pounds weight fell at the village of Slobodka, in the province of Smolensko, and penetrated nearly sixteen inches into the ground. It had a brown crust with metallic spots. *Edin. Journ. of Science*, No. 2.

Before closing our chronological register, it will be proper shortly to advert to the mention of various real or alleged meteoric masses, the dates of whose history can no longer be ascertained.

That which was preserved in the gymnasium of Abydos, as quoted by *Pliny*.

That which gave rise to the establishment of a colony at Potidæa. *Id.*

The black stone, and another deposited in the Caaba of Mecca.

The thunderbolt, described in Antar as black in appearance, like a hard rock, brilliant and sparkling, and of which the blacksmith forged the sword of Antar.

The mass of cellulsr iron, described by *Pallas*, *Chladni*, *Patrin*, &c. and found near Krasnojark, in Siberia. The tradition of the Tartars assigns to it an atmospheric origin; and the analogy of its aspect, texture, and chemical characters with those of other chemical bodies, whose descent from the air is no longer questioned, powerfully tends to confirm the tradition. Although the latter ascribes the formation of this extraordinary mass to a period which is lost in the remoteness of antiquity, its existence was first proclaimed, with the requsite circumstances of authenticity, to the learned of Europe in 1750, the year immediately subsequent to the discovery of a rich vein of iron ore, near Abakansk, by the Cossac Medvedief. As M. M. Mettich, inspector of mines, examined this vein, he remarked that it was about seventeen inches thick, and that it traversed a grey and compact hornstone, which apparently composed the whole mountain. About 150 toises to the west of this mine he discovered a mass of iron, which he conjectured might weigh unwards of thirty poods. Is was full of small, yellow, and rough stones, of the size of a kernel of the cedar cone; and it lay on the very ridge of the hill, which is covered with firs, without adhering to the rock. Being much puzzled to determine whether it had been formed naturally on the spot, or conveyed thither, he sought, with eager but fruitless diligence, for the slightest trace of any ancient iron forge. Dr. Pallas was likewise decidedly of opinion, that it could never have been produced in the rude furnaces or kilns of the Siberian miners, which were never known to yield more than fifty or sixty pounds of metal at a time; whereas the present mass, before any fragments were detached from it, weighed somewhat more than 1680 pounds. The iron is of a coarse spongy texture, little contaminated by impurities, perfectly flexible, and capable of being converted into small tools by a moderate heat. When exposed, however, to a high temperature, and especially when fused, it becomes dry and brittle, resolves into grains, and refuses to cohere or extend under the hammer. In its natural state, it is incrusted with a sort of varnish, which has protected it from rust; but when this coating is removed, or when broken in the state of bar iron, the usual process of oxidation very readily takes place. The cavities in the mass are filled with a transparent, amber-coloured substance, in the form of roundish grains or drops, presenting one or more flat and glossy surfaces. The mass has no regular form, but resembles a large, oblong, and somewhat flattened block, externally coated like the nodules of some of the blackish brown ores of iron. "This coating," says Pallas, "is also very rich in iron; and even the transparent fluor yields some pounds of iron in the hundred. Whoever will consider the mass itself, or large specimens of it, will not have the least doubt of its having been wrought by nature, since it has no one character of scoriaceous matters melted by artificial fire, or of those commonly found among volcanos. No volcanic ground, indeed, has been remarked nearer the mountains of Yenissei than the extinct craters of Daouria, situated at 1500 miles to the east.

The Siberian mass of native iron was first transported to Krasnojark, where it was found to weigh fifteen quintals. In 1772, it was conveyed to St. Petersburgh, and deposited in the collections of the Imperial Academy of Sciences. M. Patrin, who examined it in 1778, describes it as a large bomb, somewhat flattened, and partly covered with a rough ochraceous crust. So hard and compact was it in its natural state, that three or four forgers employed between ten and twelve hours in detaching from it a fragment of two pounds weight.

Of a similar description seems to have been the fragment which was found between Eibenstock and Johanngeorgenstadt.—Another, probably from Norway, preserved in the Imperial Cabinet of Vienna.—A small mass, of some pounds weight, kept at Gotha.—A mass, found under the pavement of Aken, near Magdeburg. *Loeber.*—A mass of iron from the coast of Honduras. *Annals of Phil.*—Scattered masses of black rock, containing native iron, on the right bank of the Senegal. *Compagnon*, *Forster*, *Golberry.*—A mass of iron at the Cape of Good Hope, in which Stromeyer detected the presence of cobalt. *Von Marum* and *Dankelman.*

In the *Philosophical Transactions* for 1816, there is an interesting history and account of a mass of native iron, found in the province of Bahia in Brazil, communicated by A. F. Mornay, Esq. to Dr. Wollaston. It is about seven feet long, four feet wide, and two feet in thickness, its solid contents being rudely estimated on the spot at twenty cubic feet, and its weight at 14,000 lb. The colour of the top and sides is chesnut, and the surface glossy, though not smooth, being slightly indented all over, as if hammered, while the hollow part underneath is covered with a flaky crust, whose external surface is rusty. Here we should not overlook, that the cavities, or indentations on the surface, are sometimes also observed on well ascertained meteorites. Thus one of the Siena stones is described by Mr. King, "as having many rounded cavities on its surface; as if the stone had been struck with small balls whilst it was forming, and before it was hardened, which left their impressions. And some appearances of the same kind," he adds, "were found on one of the four surfaces of another stone in the possession of Soldani." The surface of the Yorkshire stone, too, presents similar cavities or depressions. Wherever the Brazilian block is struck with a steel, it gives out abundance of sparks, and, when rubbed with a quartz pebble in the dark, it becomes beautifully luminous. It is not only magnetic, but manifests well-defined poles. Small fragments were detached from it with much difficulty, and revealed an internal crystallization, not previously noticed in meteoric iron. From the observations and experiments of Dr. Wollaston on the specimens transmitted to him, it appears that the texture of this iron is not only crystalline, but that it is disposed to break in the forms of the regular octohedron and tetrahedron, or in the rhomboid, a combination of both these forms.

"Though the fragments," observes the Dr. "are not in the least attractive as magnets, and have in themselves no polarity, they are precisely like any other pieces of the best soft iron, and assume polarity instantly, according to the position in which they are held with respect to the magnetic axis of the earth. When a long fragment is held in a vertical position, its lower extremity being then within 20° of the dip of the north magnetic pole, becomes north, and repels the north pole of a magnetic needle suspended horizontally. But this power is instantly reversed, by being suddenly inverted: so that the apparent contradiction between the observed polarity of the mass, and the seeming want of it in the fragments, is thus completely removed.

"Although Mr. Mornay reasonably expected, that this iron would not differ from the many others now on record that have been found in various parts of the world, and from his experiments was led to infer the presence of nickel, it appeared desirable to ascertain this point with more precision than he had been enabled to do, and to determine also in what proportion this peculiar ingredient of meteoric bodies might be found to prevail." Then, after detailing the steps of his process, he thus concludes:

"From the presence of nickel in this mass, we cannot but regard it as having the same meteoric origin with the various other specimens that have been found; and although in the spot whence it had been first removed Mr. Mornay discovered a bed of matter, from which it appears, by analysis, that similar iron might be formed by art, it seems by far more probable that an opposite change has really taken place, and that the whole of this supposed ore is the result of progressive oxidation during a series of years, of which we have no other evidence, and affords the sole ground on which a conjecture could be formed of the very remote period at which this problematic body has fallen upon the earth."

Since the expulsion of the Spaniards from the province of the great Chaco Gulamba, the country situated to the south of the river Vermejo, and to the west of the Parana, has been mostly abandoned. A few Indians only inhabit the district of St. Jago del Estero, to gather the honey and bees-wax which abound in the woods. These Indians discovered, in the middle of a very extended plain, a considerable mass of metal, which they reported to be iron. When the viceroy of Peru was apprized of this discovery, he was struck with the singularity of the phenomenon, because there are no hills in that part of the country, and scarcely a stone of any description is to be found within a circumference of a hundred leagues. Some individuals, regardless of every danger, and stimulated by the prospect of gain, repaired to the spot to obtain some portions of the metal, and actually conveyed specimens of it to Lima and Madrid; but the only fruit of their toils, was the assurance that the substance with which they had loaded themselves was very fine and malleable iron. According to these adventurers, the vein extended several leagues, and promised an abundant produce. The viceroy of Rio de la Plata, therefore, dispatched Don Celis to examine the mass with greater accuracy, and to fix some settlers in the neighbourhood, if he should judge the working beneficial. Celis departed, accordingly, from Rio Salado, on the 3d of February, 1783, accompanied by the requisite attendants; and, after performing a journey of seventy leagues, through a fine level country, he reached the spot, which, agreeably to his observations, is in 27° 28′ of south latitude. He found the ferruginous mass mostly buried in pure clay. Its external surface was very compact; but, on breaking some pieces from it, he perceived that its substance was full of cavities, as if the whole had at one time undergone fusion. In the course of separating 25 or 30 bits, the seventy chisels with which he had been furnished, were rendered useless. On removing the surrounding earth, he observed that all the surface which had been covered by the soil was invested with a layer of rust, of about six inches thick, and which he ascribed to the humidity of the ground. Having rent it in two different places by the force of gunpowder, he examined the deepest chasm, and found it precisely of the same nature with that of the surface, and also with the earth which was dug at a hundred paces to the east and west of the mass. As he could not conceive the latter, under the circumstances in which he found it, to be produced by any natural process, or conveyed by human means, he presumed that it must have been projected by some volcanic explosion. According to its cubical measure, and allowing a specific gravity somewhat greater than that of iron, this enormous mass should weigh about 300 quintals.

"The largest specimen of these substances which has ever been described," observes Mr. Southey, "has escaped the notice of all the philosophers who have written upon the subject.

"Walkennaer, in a note to Azara's Travels, upon the mass of iron and nickel found in the Chaco, says that two other such masses have been discovered; one which Pallas has described, and one which was dug up at Aken, near Magdeburg. Gaspar de Villagra, in his *Historia de la Nueva Mexico*, mentions a fourth, evidently of the same nature as these, and considerably larger than the largest of them. The tradition of the natives concerning it, supports the most probable theory of its origin. A demon, in the form of an old woman, appeared to two brothers, who were leading a horde or swarm of the ancient Mexicans, in search of a new country; she told them to separate, and threw down this block of iron, which she carried on her head, to be the boundary between them.

"Villagra describes it as something like the back of a tortoise in shape, and in weight about eight hundred quintals; he calls it massy iron; it was smooth, without the slightest rust, and there was neither mine near it, nor vein of metal, nor any kind of stone any way resembling it.

"The latitude where this is found is 27 N. The history of the expedition which Villagra accompanied, furnishes some clue for seeking the spot, and it might probably be discovered with little expense of time or labour, by a party travelling from Mexico to Monterry."

Humboldt's account of the Mexican sky-stone, reduces the above dimensions something more than a half; but still it remains greatly larger than any other that has been yet discovered. "In the environs of Durango," says this philosophic traveller, "is to be found insulated in the plain, the enormous mass of malleable iron and nickel, which is of the identical composition of the aerolithos which fell in 1751, at Hraschina, near Agram, in Hungary. Specimens were communicated to me by the learned director of the *Tribunal de Mineria de Mexico*, Don Fausto d'Elhuyar, which I deposited in different cabinets in Europe, and of which M. M. Vauquelin and Klaproth published an analysis. This mass of Durango is affirmed to weigh upwards of 1900 myriagrammes, which is 400 more than the aerolithos discovered at Otumpa by M. Rubin de Celis. M. Frederick Sonnenschmidt, a distinguished mineralogist, who travelled over more of Mexico than myself, discovered also, in 1792, in the interior of the town of Zacatecas, a mass of malleable iron of the weight of 97 myriagrammes, which, in its exterior and physical character, was found by him entirely analogous to the malleable iron described by the celebrated Pallas."

In the 42d and 44th vols. of Gilbert's Annals, mention is made of meteoric iron at Elbogen, in Bohemia, which originally weighed 190 lbs. A fragment detached from it, and fashioned into the shape of a coin, has the peculiar property, when put into weak nitric acid, of being attacked unequally, and of then exhibiting blackish particles, and others, of a whitish hue, in relief, whose mutual arrangements seem to depend on some law of crystallization. The Chevalier Schreibers, who first made this observation, found that it also applied to specimens of the Krasnojark mass; and he is inclined to believe, that it probably extends to all native iron that has fallen from the atmosphere.

Native iron is also supposed to have fallen near Lenarto in Hungary. *Gilb. Ann.* p. 49.

Two masses in Greenland, from which the Esquimaux manufacture a sort of small knives. Ross's *Account of an Expedition to the Arctic Regions. Edin. Journ. of Science*, No. I.

A few other detached masses of native iron have been quoted by different writers; but as they contain no nickel, and have a different texture from the preceding, their meteoric origin seems to be extremely doubtful.

From the foregoing historical review of our subject, we may safely deduce a few general observations, or corollaries.

That meteorites do really fall from the upper regions of the air to the earth, can no longer be doubted, unless we are determined to reject the evidence of human testimony. These bodies have a peculiar aspect, and peculiar characters, which belong to no native rocks or stones with which we are acquainted. Their fall is usually accompanied by a luminous meteor, which is seldom visible for more than a few minutes, and generally disappears with explosions. These bodies appear to have fallen from various points of the heavens, at all periods, in all seasons of the year, at all hours, both of the day and the night, also in all countries of the world, on mountains, and in plains, and without any particular relation to volcanos. The luminous meteor which precedes their fall, affects no constant or invariable direction. They are, for the most part, hot when they fall, and emit sulphureous vapours. As their descent usually takes place in calm, and often cloudless weather, their origin seems to be owing to some very different cause from that which produces rain or storms.

In our second volume, to which we beg leave to refer, we have unfolded our own sentiments relative to the very problematical source of these occasional visitants of our planet; and as these views still appear to us less exceptionable than any others which have been submitted to our notice, we shall glance at some of the latter with all suitable brevity.

The opinion of the Parisian Academicians, who, in the middle of the last century, maintained that the stones in question merely resulted from a stroke of lightning on the spot in which they were found, will not, in the present day, bear a moment's examination; for we have seen, that thunder and lightning do not necessarily accompany the fall of meteorites; and that these last differ from all the solid substances on the face of the globe. We will not deny, that lightning may tear up the soil, and convert it into a solid mass; but we have no proof of its competency to project masses, so formed, into an indefinite height in the atmosphere, nor to generate thousands of hard stones in fine cloudless weather.

The supposition that such concretions have been driven off from some of our volcanos, is scarcely less tenable; for the compound lavas of burning mountains are never found remote from the scene of their formation; and none of them present the aspect and characters of the bodies which we have described. Besides, most of the stony showers on record are represented as occurring when no remarkable volcanic eruption was known to have taken place. The ashes of a violent eruption have frequently, from their levity, been wafted to a considerable distance; but we are altogether unacquainted with any projectile force which can dart solid and heavy masses hundreds of leagues, through such a dense medium as the atmosphere. Mr. King, indeed, is inclined to believe, that an immense cloud of ashes, pyritical dust, and particles of iron, forcibly propelled from Vesuvius to a very great height, became condensed in its fall, took fire from its motion in the air, and its electrical elements, and thus gave birth to the Siena stones. But he does not thus account for the presence of nickel in their composition, nor for the other obvious discrepancies between volcanic ashes and meteoric stones. In order to explain the direction of the cloud which proceeded from the *north*, he has recourse to the supposition, that it was at first driven, in its course, to the northward of Siena, and afterwards urged back by a contrary current of wind. But the cloud itself, and its destinies, are alike gratuitous: and it is much more conformable to what we know of parallel cases, to conceive that the Siena phenomenon would have occurred at the time, and in the manner in which it did occur, although Vesuvius had remained in a state of perfect quiescence.

In the boldness of his speculations, M. Bory de Saint Vincent takes a still wider flight, and sends forth his meteorites from immense depths, in some early stage of the earth's existence, when ignivomous mountains, as he pompously denominates them, were endowed with propelling forces adequate to the dispersion of matter into the regions of space, in which they were constrained, for ages, to obey the compound laws of impulse and gravitation, until, in the progress of time, their spiral revolutions terminated on the surface of their native planet. Before, however, we can tamely acquiesce in the terms of such an extravagant hypothesis, we may be permitted to call for the evidence of the existence of those ancient and wonder-working volcanos, which could communicate planetary motion to chips of rock, without up-heaving the rocks themselves.

The sagacious Troili, too, in his endeavours to account for a fact which he has so triumphantly proved, labours to convince his readers that the Albereto stone must have been torn from the bowels of the earth, and projected to a great height by the powerful agency of subterraneous conflagration; and these conflagrations he conjures up at pleasure to suit his purpose. On such a supposition, however, the bursting of stones from the surface of the earth, and their ascent into the air, should be as frequently seen as their fall to the ground, and *some* of the profound openings and fissures occasioned by their violent passage through the strata, ought, before now, to have been observed; for we are not entitled to presume that they were *all* effected in the *recesses of forests*, or *closed again* after the stones had made their escape. Again, an expansive force commensurate to the conditions of the hypothesis, would occasion wide and ruinous disorder, which could scarcely fail to be observed in every inhabited country.

Of the many who contend for the atmospheric formation of meteorites, scarcely any two agree in regard to the manner in which such formation is effected. Muschenbroeck, in one part of his writings, ascribes the descent of stones from the air to earthquakes and volcanic eruptions; an opinion which later observations have disproved. In other passages, however, he leans to a modification of the atmospheric hypotheses, and attributes the origin of shooting stars to the accumulation of volatile matters suspended in the air. Whatever relation may subsist between shooting stars and fiery meteors, the former seem to move at a much greater distance from the earth than the latter, and occasion only a transient luminous appearance, in their passage through the upper regions of the atmosphere. The Dutch philosopher, however, adopts the common notion of their falling to the ground, and seems to confound their residue with *tremella nostoc*.

The late ingenious, but fanciful Patrin, who was solicitous to extend and illustrate his favourite doctrine of a regular circulation of gaseous fluids between the schistose strata of the globe and its surrounding atmosphere, very confidently deduced from this fancied circulation the occasional ignition and concretion of portions of these fluids in the higher regions of the air. But it is a sufficient confutation of his theory, that it rests on assumed and very improbable foundations.

In aid of the same cause, M. Salverte had recourse to a very liberal exhibition of hydrogen gas, kindled by electricity during thunder storms. But we have shown that thunder and meteors are distinct phenomena; and this gentleman's magazines of hydrogen remain to be proved.

His countryman, M. Izarn, has dragged his readers into a tedious and somewhat obscure exposition of his own sentiments, founded on the principles of chemical combination; but we are not certain that we perfectly comprehend his meaning; and, at any rate, his inferences depend on admissions of gaseous substances, arranged in spherical masses in the superior regions of the air, and occasionally detached from their insulating medium, and brought into one capable of combining with them; a disposition of things which may, or which may not exist, but of which we are entirely ignorant,

M. Seguin thinks it not improbable that the constituent principles of meteorites being transported by chemical or mechanical means into the upper portions of the atmosphere, where a vacuum, the cause of the noise of thunder, is produced, there remain suspended by solution or otherwise; but, although disseminated, being pressed by the external strata which fill the vacuum, they unite, conglomerate, and form a mass, the more considerable in proportion to the quantity of materials which it encounters in this place. Now, granting to this philosopher his conjectural premises, we have again to repeat, that the fall of meteorites is independent of thunder, and that the noise of the explosion, which so much resembles thunder as to have been often confounded with it, is posterior to the consolidation of the mass.

In the 75th volume of the *Annales de Chimie*, M. Marcel de Serres enters into the discussion of the origin of meteorites: but much of his paper is occupied with a very rapid and imperfect recapitulation of the instances of their occurrence, and incidental notices of showers of sand, &c. His decided bias, however, is to the generation of these bodies in the atmosphere, from the contact of all the matters carried up by the evaporation, and the formation of metallic particles during the ignition. Yet, his solution of the problem is, on the whole, far from *luminous;* nor is he altogether insensible to the difficulties with which it is encompassed. The total absence of oxygen in the Lissa stone, in particular, strikes him very forcibly. It is, besides, extremely difficult to conceive the machinery by which an immense field of gaseous, or highly attenuated matter in the air, can be instantaneously reduced into the compass and consistency of a solid compact mass, of very moderate dimensions, and suspended in the air, as if by enchantment, until it explodes, and is precipitated to the earth.

Dr. Reynolds' Outline of the Theory of Meteors does not very materially differ from some of those to which we have just alluded; for it proceeds on the supposition that minute portions of the earthy and metallic compounds of the surface of the globe, being exposed to the sun's influence, will be volatilized by the absorption of heat, and thereby assuming the state of elastic fluids, will ascend, until they arrive at media of their own density, where, congregating into immense and highly concentrated volumes, they will explode, and exhibit all the appearances of meteoric stones and showers. But the elevation of particles of stone and iron, however much attenuated, to the enormous height of a hundred miles above the earth's surface, is scarcely conceivable on any principle with which we are acquainted; and their combustion and explosion, in such a lofty and frigid medium, are alike unsusceptible of satisfactory explanation.

We know not that Dr. Murray is more successful, when he insinuates, in one passage, that these bodies spring from the thunder storm, and when he resorts, in another, to the solvent agency of hydrogen, and the changes produced on different substances by the influence of the electric fluid. That truly philosophic traveller and observer, Humboldt, who studied the present subject with much attention, is decidedly of opinion, that meteorites are foreign to the confines of our atmosphere.

The romantic notion, that they are the products of lunar volcanos, has derived some countenance from the speculations of the celebrated La Place, Poisson, Dr. Hutton, and others, who have demonstrated the abstract proposition, that a heavy body, projected with a velocity of about 6000 feet in a second, may be driven beyond the sphere of the moon's attraction into that of the earth. But the existence of any such volcanic force in the moon is purely hypothetical; nay, the existence of volcanos at all in our satellite, begins to be very seriously questioned. Overlooking these considerations, however, as well as the combustion of sub lunar substances without the contact of atmospherical air, the occasional arrival of fragments of such lava on the surface of the earth would, on a fair computation of chances, imply such a copious discharge of volcanic matters, that the moon, by this time, should consist of hardly any thing else. Further, if we may be allowed to reason from analogy, we should expect the volcanic productions of the moon to exhibit varieties of aspect and composition, and not a definite and precise number of the same ingredients. The resistance which a body falling from our satellite would experience in its transit through our atmosphere, combined with the two-fold motion of the earth, may sufficiently obviate the ordinary objection derived from the comparatively moderate impulse with which meteorites usually impinge on the earth's surface, but affords no solution of the more formidable difficulty, deduced from the want of coincidence, in point of time, between the descent of these stones and the moon's position, she being as often in their nadir as in their zenith.

Dr. Chladni, who, for years, has devoted much of his attention to the history of meteoric stones, long since intimated his belief, that they are cosmical bodies, or fragments of planetary matter. As earthy, metallic, and other particles, form the principal component parts of our planet, among which iron is the prevailing ingredient, other planetary bodies, he affirms, may consist of similar, or, perhaps, of the same component parts, though combined and modified in a very different manner. There may also be dense matters, accumulated in smaller masses, dispersed throughout infinite space, and which, being impelled either by some projecting power or attraction, continue to move until they approach the earth, or some other body, when, being overcome by gravitating force, they immediately fall down. By their exceeding great velocity, and the violent friction in the atmosphere, a strong electricity and heat must necessarily be excited, by which means they are reduced to a flaming and melted condition, and great quantities of vapour and different kinds of gases are thus disengaged, which distend the liquid mass, until, by a still further expansion of these elastic fluids, the whole at length explodes.

Our principal objection to this sort of reasoning is, that the leading idea of portions of cosmical matter being allowed to revolve in space, and to terminate their career on the surface of a planetary orb, is stated in terms too vague and gratuitous; but it assumes somewhat of reason and consistency, when propounded with the particular development of which we have conceived it to be susceptible.

Although we have now allotted to this curious subject as much space as our limits will permit, we are still far from having exhausted its details; and we shall, therefore, conclude by recommending to the perusal of our inquisitive readers, Stepling *de Pluvia Lapidea;* Troili's Essay, already cited; Izarn *Lithologie Atmosphérique;* Bigot de Morogues, *Mémoires Historiques et*

Physiques, sur les Chutes de Pierres, 2 T.; Chladni *on the Siberian mass of Iron*, and his *Catalogue of Meteors*; Gilbert's *Physical Annals*; *Opusculi Scelti*; Bjorn *de Indole et Origine Aërolithorum Disquisitio*; Biot *Rélation d'un Voyage fait dans le Department l'Orne, &c.* Böttiger's *Observations on the Accounts given by ancient Authors of Stones said to have fallen from the Clouds*; Fulda's *Memoirs on Fire-Balls*; Cavallo's *Elements of Natural Philosophy*, vol. 4th.; Klaproth *on Meteoric Stones*; King's *Remarks concerning Stones said to have fallen from the Clouds*; Soldani's *Account of the Tuscan Meteor*; and various recent and scientific communications, contained in the transactions of learned societies, and in periodical journals, foreign and domestic; to the most important of which we have occasionally referred in the course of the article. (H. N. A.)

METEOROLOGY.

Meteorology may be defined that department of physical science which treats of atmospherical phenomena. This definition is immediately suggested by the original import of the word, as derived from μετεωρα, *meteors*; and λογος, *a discourse*. The word *meteors*, indeed, has, in our language, been almost exclusively confined to those *luminous* bodies, which are seen occasionally in our atmosphere, and whose appearance and motion have not hitherto been reduced to any definite law. In Greek, however, the word μετεωρα, (from μετεωρος, *high* or *elevated*,) was indiscriminately applied to all bodies, whether luminous or opaque, that appeared in, or were deposited from the atmosphere; and the term meteorology is still used in the same, or even a more extended acceptation. It denotes the investigation, not only of those atmospherical phenomena that are of comparatively rare occurrence, and may be more properly denominated *meteors*, but of the various changes also, that are observed to take place in the state of the atmosphere itself. But for this extended application of the word, the subject would be comparatively uninteresting, and could with little propriety be dignified with the appellation of a science. Bodies that appear only at irregular intervals, at a considerable distance from the earth, and perhaps but for a few seconds at a time, though unquestionably deserving of being noticed and recorded, are not likely soon to be subjected to any thing like accurate investigation, or ever to be interesting, otherwise than as objects of curiosity or conjecture. The case, however, is very different with those atmospherical phenomena, which, from their frequency or vicinity to the earth, immediately affect the comfort and subsistence of its inhabitants. These must be at all times interesting, and in the progressive advancement of physical science they are becoming every day more so, in consequence of the invention of various instruments, by which their effects may be more accurately estimated; and their causes, it is to be hoped, in due time unfolded and explained. It is chiefly to these last, therefore, as constituting the great principles of meteorological science, that we propose directing the attention of our readers in the present article, and shall purposely avoid dwelling, at any great length, on the state of meteorology previous to the invention of those instruments, by which, in modern times, this department of science has been enriched, or on such phenomena as have not yet been made the subject of any thing like direct experiment.

From the nature of the facts that form the subject of meteorological research, it might be inferred that they must, in all ages of the world, have attracted the attention of mankind. The diversified appearances of the sky, the changes in the temperature of the air, and the other vicissitudes in the state of the weather, can hardly fail to strike even the most careless observer; nor does it require any great intellectual exertion to perceive that these changes have an immediate and powerful influence, not only on the feelings and comfort of sentient beings, but also on the vegetable productions of the earth. To men in a rude state of society, such phenomena would be peculiarly interesting. Necessarily led, from their employments and mode of living, to spend a great proportion of their time in the open air, they would have frequent opportunities of observing the various appearances that preceded any material change in the state of the atmosphere, while, from the want of those conveniences which are enjoyed only in a state of comparative civilization and refinement, their comfort, as well as their curiosity, would prompt them to recollect every circumstance that seemed to predict the approach of such changes. We find, accordingly, that from the earliest times these phenomena have excited a general interest in all countries, and in every stage of society; nor is there any other subject, perhaps, on which popular maxims have been so numerous or so universally prevalent.

The first attempt to collect and reduce to any thing like a systematic form, the various prognostications of the weather, is to be found, we believe, in the writings of Aristotle, and his disciple Theophrastus. Long before their time, indeed, the Egyptians and other eastern nations, had recorded many interesting facts regarding atmospherical phenomena; but they appear to have considered these only as a branch of astronomy or astrology. Aristotle, in his book *de Meteoris*, treats the subject as a separate science, and in addition to the observations of his predecessors, records also a variety of his own, bearing evident marks of all that accuracy and acumen for which he was so eminently distinguished. In as far as observation is concerned, few were better qualified than he was to conduct meteorological researches, and we have only to examine his remarks on *dew*, to perceive how nearly he approached on some subjects, to the discoveries of more enlightened times. Unacquainted, however, as he was, with both the chemical and mechanical constitution of the atmosphere, his speculations were often necessarily vague, fanciful, and inconclusive; and notwithstanding all his ingenuity and industry, meteorology, as a science, could hardly be said at that period to have had an existence.

The more profound speculations of Aristotle, were succeeded by the treatise of his pupil Theophrastus, in which he collected, and arranged under distinct heads, the commonly received opinions on the subject of meteorological phenomena. The work consisted of four general divisions, viz.—the prognostications of rain, of wind, of storms, and of fair weather; and it may be inferred from these titles, that if the treatise was less scientific than that of his master, it was calculated to be more popular. The darkness which at that time hung over every department of physical science, afforded little prospect, even to the philosophical inquirer, of his being able successfully to investigate the causes of phenomena, so irregular in their recurrence, and so various in their appearance; but every man would feel more or less interested, in making himself acquainted with rules or maxims, however empirical, which might enable him in any degree to predict the approach of such phenomena. We find, accordingly, that the writings of Theophrastus soon became the standard work on meteorology, to which succeeding writers on the subject made neither very numerous, nor very important additions. It constituted the groundwork of the *Διοσημεια*, or Prognosticks of Aratus, afterwards translated, together with the phenomena of the same author, into Latin verse by Cicero. A fragment of this juvenile essay of the Roman orator, is still to be found among his works, and affords us no very favourable specimen, either of the poetical talents of Cicero, or of the meteorological knowledge of the ancients.

It is unnecessary to waste the time of our readers, in attempting to trace the progress of this branch of philosopny, during the later period of the Roman history. In the writings of Virgil, and many other classical authors, we find frequent allusions to the subject; but while popular prognostications were no doubt multiplying, meteorology, as a science, made little or no advancement. A great many facts, indeed, are to be found in Pliny, and Lucretius has attempted to assign these to their respective causes; but besides that the facts themselves are of a vague and general nature, the absurdities and superstitions with which they are blended, render them a fitter subject for the study of the moralist, than the investigation of the natural philosopher.

During the ages that succeeded the final overthrow of the Roman empire, it is not to be supposed that the science of meteorology made any sensible progress. These were, proverbially, the ages of darkness, when not only were the lights of ancient literature and science extinguished, but the march of the human intellect seemed to be for a time retrograde. To the irruption of the barbarous nations from the north has been ascribed the ruin of all that was most valuable in the monuments of antiquity, while the period of their reign is almost universally regarded as a blot in the history of the human race, on which the historian dwells only in the language of lamentation or contempt. This is no doubt, to a certain extent, true; and the condition of Europe, for several centuries of the period in question, did certainly present a striking contrast to the brighter era of the Roman government, when conquest was uniformly accompanied with all the refinements of literature and philosophy. With the exception, however, of the first two or three centuries, while Europe was still in an unsettled state, we are not sure that what are commonly called the dark ages have been always fairly represented, or that they are in reality worthy of the unmeasured reprobation with which they are generally treated Were we more intimately acquainted with them, we should perhaps find that not a little of the darkness in which they are supposed to have been involved, has arisen from our ignorance of their true character, and that the origin of many of those sciences which constitute the glory of modern times, may be traced to the very men whom we have been taught to regard as little better than barbarians. But however this may be, we cannot agree with those who represent meteorological science as having suffered largely in the common ruin which the destruction of the Roman empire brought on the philosophy of the ancients. Meteorology, as a science, had, in fact, little to lose, and as to the popular prognostications of atmospherical phenomena, which constituted by far the largest and most interesting portion of the subject, even among the Romans, they were just as likely to have been discovered and preserved by the barbarian conquerors as by their more civilized predecessors. Few, if any of these prognostics were the result of philosophical investigation, or profound research. They were of that nature, that philosophy could give no rational explanation of them, but as matters of fact they were equally level to the capacity of the illiterate and the learned; and in proof of this, we need only observe, that many of the maxims which are to be met with in classical authors respecting the changes of the weather, are still found in this as well as other countries, and that too among a class of men, who cannot be supposed to have derived their information from the writings of Greece and Rome. A general view of these commonly received opinions will comprehend all that was valuable in the science, if it may be called so, previous to the general use of meteorological instruments, or, in other words, up to about the middle of the last century.

Our limits will not permit us to enter into a minute detail of the maxims alluded to above, nor are they of so much importance as to require a particular enumeration. It may be useful, however, to notice some of the most popular, and what have been generally considered the most certain prognostications of approaching changes in the state of the weather, as serving at once to illustrate the history of meteorology, and to show what are still the most important desiderata on this branch of physical science. It would be difficult, indeed, if not impossible, to make such a classification of these prognostics, as to include the various and often fanciful opinions, that have prevailed on this subject. The most commonly received, however, may be arranged under the two following classes: 1st, The appearance of the sky; and, 2d, Phenomena that take place at or near the surface of the earth. In illustrating these, we shall have an opportunity of noticing certain atmospherical phenomena which cannot well be omitted, but which could not with so much propriety be introduced in any other part of this article.

To the first class belong those luminous bodies that occasionally appear in the atmosphere, and which have been denominated *meteors*, or *falling stars*. These bodies appear to be of different magnitudes, and even of various forms, though this last circumstance may perhaps be the effect of optical deception. In general they seem to be globular, continuing visible only for a few seconds, and moving with great velocity. Their course is on some occasions in a straight line, and on others curvilineal, rendered more distinct by the tail or luminous train which they leave behind them; and before disappearing, they are sometimes separated into several smaller bodies, accompanied with an explosion resembling thunder, more or less loud according to their magnitude or distance. It was long supposed, and has now been proved by the most incontrovertible evidence, that these explosions are followed by a shower of solid bodies of a stony or metallic substance, some of which have even appeared luminous in their descent after the explosion, and have been taken up before they had time to cool: (See METEORITE.) This last phenomenon, indeed, is of comparatively rare occurrence. Thousands of small meteors, as various in magnitude and brilliancy as the fixed stars, have been seen in all seasons, and in almost every variety of weather, unaccompanied either with explosions, or the deposition of solid substances; nor is it certain that even the larger and more luminous meteors, such as that of 1783, described by Cavallo, or one in 1811, an account of which was given by Professor Pictet in the *Bibliothéque Britannique* for May 1811, are always followed by a fall of meteoric stones. On the other hand, these stones have sometimes been observed to fall after a loud detonation, when no meteor was visible, though this may perhaps be accounted for, from its having been obscured either by the superior light of the sun, or the intervention of clouds. But however this may be, the appearance of large meteors, and the fall of meteoric stones, or, as they have very improperly been called, *aeroliths*, are phenomena that appear to be closely connected, and this is almost all that is known upon the subject. We deem it quite unnecessary, therefore, to enter into a minute account of the attempts that have been made to classify these luminous bodies, according to their form, colour, or magnitude. Whether they are all of the same origin, but varying in appearance, in consequence either of their different distances, or of some peculiar state of the atmosphere, or whether they are essentially different in their nature, are questions to which, in the present state of meteorological science, no answer can be given. As prognostics of the weather, they have in general been supposed to predict wind, as appears from various passages in ancient authors; and it is also commonly believed, that the wind which follows will blow from the point of the compass towards which the meteor is observed to move. One at least of the various hypotheses which have been proposed to account for these phenomena is interesting, inasmuch as it appears to explain, in certain cases, the connection between the motion of the meteor and the direction of the wind.

The hypothesis to which we allude, is that which ascribes meteors to certain vapours arising from the earth, and becoming ignited in the higher regions of the atmosphere. The origin of this opinion may be traced to Aristotle; but from the discoveries in chemistry, of which that author was in a great measure ignorant, it has assumed, in the hands of the modern philosopher, a more definite form. Halley, and after him De Luc, has endeavoured, on this principle, to account for some at least of the circumstances attending the appearance of luminous meteors. The latter supposes that falling stars proceed from a phosphoric fluid, ascending from some spot of the surface of the earth, which becomes visible only when, by decomposition in the higher regions, it takes fire, and light is disengaged. If such a fluid can be supposed to rise in a continued column, without mixing with the atmosphere, or being dispersed by wind, there is no difficulty in conceiving how it may produce the appearance of a falling star. When the upper extremity of the column has reached such a height as to be in a great measure above the region of the clouds and moisture, it may, from the dryness of the air, take fire spontaneously, as phosphorus is known to do when exposed to the atmosphere in its ordinary state; and ignition having once commenced, it may be communicated backward to successive portions of the column, till it arrives at a portion of the atmosphere sufficiently moist to extinguish it, or at some point where the column itself has been broken and separated. In these circumstances, it is obvious that the appearance would be precisely that of a falling star; and Mr. Forster has ingeniously applied the hypothesis, to account for the apparent relation between such phenomena and succeeding gales of wind. It has been long known that different, and even opposite currents of wind, may exist at different heights in the atmosphere at the same time; and the author just referred to has found, from various experiments and observations, that when the wind near the surface of the earth changes, it frequently blows from the same point from which the current above had previously blown. He observes, therefore, that De Luc's hypothesis, though he is far from embracing it as satisfactory, will sufficiently account for the relation above stated, by supposing that the column of phosphoric fluid is bent, previous to ignition, in the direction of the upper current; so that, when ignition commences, the luminous body moves towards the point from which that current then proceeds, and from which the lower current is afterwards to blow. It is a prognostication of wind, then, only in so far as it indicates a change that has already commenced in the higher regions of the atmosphere, but which has not yet taken place near the surface of the earth.

The above hypothesis, fanciful as it may appear, and inadequate as it unquestionably is to account for all the phenomena of meteors, points to a plausible explanation of another luminous appearance, the cause of which has not yet been ascertained, and which, though differing in many respects from the bodies above described, bears a sufficiently close resemblance to them, to be classed under the general head of meteors. We allude to the well known light called *Ignis Fatuus*, *Jack with a lantern*, or *Will with the wisp*, so named from the superstitious notions which have been attached to its appearance. It is generally seen in dark nights, over boggy and marshy ground, sometimes at rest on the surface, but generally in motion at the height of five or six feet, skipping from place to place, and frequently changing both in magnitude and form. On some occasions it is observed to be suddenly extinguished, and afterwards to reappear at a distance from its former position. Those who have endeavoured to examine it more closely, or who have been accidentally led to approach it, generally remark that it moves away from them, and with a velocity proportional to that with which they advance, a circumstance which has had no small influence on the fears of the ignorant and superstitious. A particular account of the ignis fatuus, as seen on two different occasions, will be found in Cavallo's Elements of Natural Philosophy, Vol. III. p. 329.

To apply the above hypothesis to the explanation of this phenomenon, let us suppose that some such phosphoric fluid as that mentioned by De Luc, arising from the decomposition of animal or vegetable substances, passes into the atmosphere, and continues to float there without mixing with the atmosphere itself, or being dissipated by the wind. We can then conceive that this fluid, having become luminous by some sort of ignition, at the place where it is least affected by the intermixture of moisture or other substances, successively communicates with other portions of itself, so long as the column continues unbroken. In this way the luminous body will move from place to place, following the direction which the fluid had previously taken, and it will appear more or less brilliant, according to the quantity or purity in which the fluid exists at any given point. The occasional disappearance of the light may be owing to an interruption in the column, or to the quantity of phosphoric matter being so small as not to be visible till the ignition arrive at another point, where the inflammable matter is more abundant, and consequently reappears. We could anticipate many difficulties and objections to this explanation, which we doubt not will readily occur to our readers. But though we are not aware of any which might not admit of a plausible refutation, enough has been said on a subject that requires numerous and more accurate observations than any that have yet been made, to furnish the basis of a satisfactory theory.

Besides the meteors already described, there are other luminous appearances occasionally observed in the atmosphere, which belong also to the first class of prognostics, viz. *Halos*, *Parhelia*, or *Mock Suns*, *Paraselenia*, or *Mock Moons*, and the Rainbow. The investigation of these phenomena properly belongs to Optics, and to that article we refer for an account of such of them as have not already been described in the course of this work. (See HALO.) We notice them here, only because they are supposed to indicate certain approaching changes in the state of the weather. The luminous circle which is sometimes seen around the heavenly bodies, but especially the sun or moon, and which has received the name of Halo, or Corona, has, from a very early period, been regarded as a certain prognostication of stormy weather, accompanied with rain or snow, according to the climate or season of the year. It frequently happens, that, in the outer edge, or circumference of this circle, there is a part less distinctly defined than the rest, apparently owing to the contact of a denser cloud; and it has been remarked by shepherds and others, who have frequent opportunities of observing this phenomenon, that the storm generally comes from that point of the compass, towards which this indistinct portion of the circle, or opening as it is called, was directed. If there is any foundation for this remark, it may perhaps be accounted for on the principle already stated, regarding the change of wind in the higher and lower regions of the atmosphere. The current that is to bring the approaching storm may have set in above, before the halo disappears, and by accumulating the clouds upon it from that quarter, produce the indistinctness alluded to. This phenomenon, as well as its modifications the Parhelion and Paraselene, is obviously connected with a change of weather, only in so far as it indicates some peculiarity in the state of the atmosphere. The same remark applies to the rainbow, though this last is rather a concomitant, than a prognostication of rain. It has been remarked, however, that a rainbow in the morning is frequently followed by showers, while one in the evening forebodes fair weather.

It has been a long established, and generally received opinion, that the phases of the moon have a certain influence on the weather, and these have accordingly furnished various prognostications, which may also be referred to the first class. It is quite conceivable, on philosophical principles, that the atmosphere may be differently affected, in the same way as the waters of the ocean are, by the different positions of the sun and moon, relatively to the earth; and that the result in certain cases, may be a tract of settled or tempestuous weather, according to circumstances. At the same time the subject is still involved in great uncertainty; nor does there appear to be any foundation for the common opinion, that if the new or full moon happens about midnight, dry weather will follow; but if it takes place about noon, rain may be expected. The rule does no doubt hold in many instances; but on looking over our observations for a series of years, we find that it also frequently fails.

But the most fertile source of prognostics of the first class, is to be found in the various and ever changing appearance of the clouds. As the proximate cause of rain or snow, they have in all ages been regarded as affording the surest and most direct intimation of approaching changes; and there are few perhaps who are not conscious of having frequently looked, as it were instinctively, to the appearance of the clouds, in order to form some opinion or conjecture respecting the future state of the weather. At the same time, there are few subjects perhaps on which there exists so great a diversity and vagueness of opinion. Indications drawn from the appearance of the clouds themselves are exceedingly indistinct, unless when accompanied with other circumstances which render them more definite, such as the colour of the sky at sun-rise or sunset, the settling of clouds on the summit of hills, the appearance of mist or fogs at particular periods of the moon's age, &c. and though there are no doubt certain forms and modifications of clouds, which nine perhaps out of ten *weather-wise* persons would, without hesitation, pronounce indications of rain or snow; yet, if they were required to assign a specific reason for their opinion, scarcely two of them would be found exactly to agree. This uncertainty arises necessarily from the rapid changes which the clouds undergo, as well as the endless variety of forms which they assume, circumstances which seem to preclude the possibility of any thing like classification, or accurate description. An attempt, however, to supply this desideratum, was made a few years ago by Mr. Howard, a philosopher to whose ingenuity and researches the science of meteorology is not a little indebted; and though his system has been pronounced fanciful, which is perhaps to a certain extent true, it is even in its present state highly deserving the attention of meteorologists, and will in all probability sooner or later become the standard nomenclature of the clouds. As this part of our subject is designed to be strictly popular, we shall abstain at present from saying any thing on the origin and formation of clouds, and simply state the characters by which they are distinguished and described in the system referred to.

Mr. Howard defines a cloud, a visible aggregate of minute drops of water suspended in the atmosphere, and includes in this definition every such aggregate, whatever be its position relatively to the observer. Of course he comprehends under the term cloud, what are commonly called *mists* or *fogs*, because at a greater distance or elevation they are found to assume all the appearance, as they possess, according to his definition, all the qualities of clouds. He then proceeds to define the various forms and modifications of clouds, which he arranges under the seven following classes.

1. Cirrus.—A cloud resembling a lock of hair, or a feather. Parallel flexuous, or diverging fibres, unlimited in the direction of their increase.

2. Cumulus.—A cloud which increases from above in dense, convex, or conical heaps.

3. Stratus.—An extended, continuous, level sheet of cloud, increasing from beneath.

These three, Mr. Howard denominates simple and distinct modifications, constituting, as will immediately appear, the elements of every other variety. The two next are of what he calls an intermediate nature.

4. Cirro-cumulus.—A connected system of small roundish clouds, placed in close order, or contact.

5. Cirro-stratus.—A horizontal, or slightly inclined sheet, attenuated at its circumference, concave downward, or undulated. Groups or patches having these characters.

Lastly, says Mr. Howard, there are two modifications, which exhibit a compound structure, viz.

6. Cumulo-stratus.—A cloud in which the structure of the cumulus is mixed with that of the cirro-stratus, or cirro-cumulus. The cumulus flattened at top, and overhanging its base.

7. Nimbus.—A dense cloud, spreading out into a crown of cirrus, and passing beneath into a shower.

We have given these definitions in Mr. Howard's own language, but our limits will afford room only for a very condensed abridgment of his illustrations, and we refer our readers to the treatise itself, published in Tilloch's *Philosophical Magazine*, or Nicholson's *Journal*, vol. xxx. p. 35.

The Cirrus, he observes, is always the least dense, and generally the most elevated modification of clouds, sometimes covering the whole face of the sky with a thin transparent veil, and at other times forming itself into distinct groups of parallel threads, or flexuous fibres. Its height, according to Mr. Dalton, is from three to five miles above the earth's surface. It is generally found to be an indication of wind. When formed into horizontal sheets, with streamers pointing upwards, it indicates approaching rain; with depending ing fringe-like fibres, it is found to precede fair weather.

The cumulus is generally of dense structure, appearing after a clear morning, increasing from above, where its surface is convex, and forming, at its greatest magnitude, a pile of irregular hemispherical cloud. This takes place early in the afternoon, about the time of the greatest heat, and gradually diminishes towards evening, when it disappears. In this case it is an indication of fine weather.

The stratus is of moderate density, and comprehends those creeping mists which rise from valleys and lakes in calm evenings. It frequently disappears in the morning, and is then an indication of the finest weather.

The cirro-cumulus appears to be formed by the descent of the cirrus, the oblique denser tufts of the latter changing into the spheroidal form, when the cloud assumes the appearance of a ball of flax with one end left unwound or flying out. The cirro-cumulus sometimes consists of distinct beds, floating at different altitudes, the clouds appearing smaller and smaller, till they are lost in the blue expanse. It is most frequent in summer, and, when permanent, affords one of the surest indications of increasing temperature, and fine weather.

The cirro stratus assumes various appearances, from its being frequently connected with other modifications. By itself it is always an attenuated sheet, or patch, of an uniform hazy continuity when viewed over head, and of great apparent density towards the horizon. In this state it gives rise to the phenomena of halos, mock suns, &c. and indicates depression of temperature, wind, and rain. When it alternates with cirro-cumulus, the prognostic is doubtful. It is frequently seen resting on the summit of high hills, and in this state has been long regarded as foreboding rainy weather.

The cumulo-stratus is that fleecy cloud which is sometimes observed to settle on the summit of a cumulus, while the latter is increasing from beneath. It usually prevails in the completely overcast sky, and apparently without any regard to temperature, as it is found to precede either a fall of snow or a thunder-storm. Before the latter, it is frequently to be seen in different points of the horizon, rapidly swelling to a great magnitude. Its indication is doubtful, and must be determined by the prevalence of the other modifications that accompany it.

The nimbus generally appears in the form of a dense inverted cone of cloud, the upper part of which spreads in one continuous sheet of cirrus to a great distance from where the shower is falling. When the total evaporation of the cloud that remains after the shower takes place, it is reckoned a prognostic of fair weather. When the nimbus appears by itself, it generally moves with the wind, but when formed in the midst of cumuli, it sometimes moves in a contrary direction. This is often the case with thunder showers.

We do not think it necessary to pursue this subject any farther. The above sketch will be sufficient to enable such of our readers as are engaged in meteorological pursuits to record the appearance of the clouds, according to Mr. Howard's classification; and those who wish for farther information upon the subject may consult, besides the works already referred to, Forster's *Treatise on Atmospheric Phenomena*.

We come now to enumerate some of the prognostics of the second class, viz. those that are derived from phenomena, which are observed on the surface of the earth, or at least in the lower regions of the atmosphere. These phenomena are of various kinds, such as the expansion and contraction of flowers—the motions and cries of certain animals—painful sensations in the human body, &c. and though many of them are no doubt fanciful, yet others appear well entitled to the attention of meteorologists. Some of them indeed, especially such as are drawn from the economy of plants, admit of a philosophical and satisfactory explanation, as every body must know who is in any degree acquainted with phisiological botany. Thus it is stated, by Sir J. E. Smith, that "the *Convolvulus arvensis*, *Anagallis arvensis*, *Calendula pluvialis*, and many others, are well known to shut up their flowers against the approach of rain; whence the *Anagallis*, (or *Pimpernel*.) has been called the poor man's weather glass." It has also been ascertained, that the *Parliera hygrometra*, a Peruvian plant, uniformly contracts its leaves at the approach of rainy weather, which it predicts with the greatest certainty. See BOTANY. In these, and many other instances that might be given, the irritability of the plant is obviously excited by some change in the state of the atmosphere, which change is either the immediate cause, or concomitant of rain.

It is probably owing to some atmospherical influence of a similar kind on the animal system, that the peculiar cries or motions of some beasts, and certain sensations in the human body, are found to indicate changes in the weather, though it may be difficult, or in the present state of science, even impossible to explain that influence. Thus, it has been long observed, and very generally believed, that rain may be expected when swallows are observed frequently dipping their wings in the water over which they are flying—when the crow or the peacock cries louder and more frequently than usual—when water-fowl are particularly clamorous and active—when dogs appear unusually dull and sleepy—when the croaking of frogs is loud and general—or when worms are seen in great numbers on the surface of the earth. It is commonly supposed too, that the noise of sea gulls about the coast, and the approach of the porpus and dolphin to the shore, are certain indications of a storm at sea, and wind is generally expected at land when pigs are observed to run about with evident signs of uneasiness. It is equally well known, that persons subject to rheumatism and other similar diseases, or who have accidentally suffered injury in any of their limbs, generally feel more acute pain in the part affected before a change of weather, than at any other time; and we know instances in which these pains are most severe, before or during a sudden depression of the barometer. This coincidence points to something like an explanation of the phenomenon; but we avoid at present proposing any thing on the subject. Neither do we think it necessary to enter at greater length into a detail of facts with which our readers in general must be familiar, and of which they will find an extensive and amusing collection in Forster's treatise on Atmospheric phenomena, formerly referred to. We would only remark, in conclusion, that these popular prognostics, fanciful as many of them unquestionably are, and connected as they have too frequently been with the most absurd and ridiculous superstitions, ought nevertheless to find a place in every meteorological register; and to overlook them, is to reject the means which nature herself seems to have pointed out, for investigating her operations in a very interesting class of phenomena. We are aware, indeed, that the modern philosopher, who fancies that he can never depart far enough from the beaten track of vulgar opinions, may be disposed to smile at the idea of calling in the observations of the illiterate, to aid him in his scientific pursuits, or of attaching any importance to the pretended discoveries, as he may think them, of a class of men, who are always ready to trace cause and effect between any two events, however unconnected they may in reality be, provided they happen about the same time, or nearly at the same place. He ought to remember, however, that what has been stated as matter of fact by thousands in every age and country, as is the case with many of the prognostics alluded to above, is not to be rejected because it may appear to him fanciful or absurd—that instead of endeavouring to set it aside with a sneer, his own philosophy calls upon him to investigate the reality of the alleged phenomena in the first instance—and that, if it be as it is represented, he is bound by the principles of the same philosophy to admit it as a fact, whether he can assign the cause of it or not. He might be reminded too, of what is perhaps a very humiliating consideration, but not on that account the less true, that the shepherd, who is totally ignorant of the constitution and properties of the atmosphere, and altogether unacquainted with the laws which regulate the distribution of its heat and moisture, can, by his own experience and observation, predict the changes of the weather at a greater distance and with more certainty than the philosopher is able to do, with the aid of all the discoveries of modern science. This indeed, is not the only, nor as some may be disposed to think, the most interesting object of meteorological pursuits; but while it is in itself of generally acknowledged importance, it serves at the same time to demonstrate, that some at least of the popular maxims that prevail on the subject, are founded on fact, and are in reality the lessons which are taught in the school of nature herself.

It is far from our intention, by these remarks, to undervalue the researches of the experimental philosopher, or to insinuate that the study of meteorology should be confined to the collection and arrangement of such phenomena as have been stated above. On the contrary, we admit, that these phenomena, of themselves, can afford no accurate information, either as to the nature or extent of atmospherical changes. They may indicate these changes, but their indications are not susceptible of being correctly measured or definitely expressed. They are the result of certain influences exerted by the atmosphere in certain circumstances; but, like the expansions and contractions of the thermometer in its rude state, before the temperatures of melting snow and boiling water were ascertained to be fixed points, they are vague and indefinite quantities, and it remains therefore for science to supply this desideratum by the application of instruments, which, while they detect the operation of the same causes, may shew likewise the amount of that operation. Still, however, there is nothing unphilosophical in supposing that there may be many substances, both in the animal and vegetable kingdom, more readily affected by atmospherical changes, and consequently acting as meteorological instruments of greater delicacy than any that philosophy has yet devised, or art constructed; and it can never, therefore, be derogatory to the honour of science to avail itself of the aid of any class of phenomena, even though they may have been long and familiarly known to the vulgar and illiterate. Meteorology has already been indebted to some of the most common of these phenomena for the most valuable instruments that it now possesses; and there is nothing that forbids us to hope, that a more careful investigation of the above, and other similar facts, may not lead to the discovery of more delicate and important instruments than have yet been employed.

Though, in the preceding sketch, we have purposely confined ourselves to the popular view of meteorology, we are aware that this branch of our subject is far from being exhausted: but to have entered on a more lengthened detail, however interesting, would have exceeded the limits prescribed to the whole of this article. Our object, therefore, has simply been, to give our readers a specimen of what meteorology was in its early state, and of the progress which may be made in the investigation of the subject, independent of the instruments by which the researches of modern times have been assisted, and to which we apprehend the attention of philosophers has been too exclusively confined. We proceed now to consider the nature of these instruments, and the discoveries to which they have led.

Of Meteorological Instruments.

The atmosphere, as defined in another part of our work, is that invisible fluid which surrounds the earth on all sides, and which has been found, by various experiments, to be heavy, compressible, and elastic. For an account of the chemical and physical properties of this body, we refer to our articles Atmosphere, Chemistry, Pneumatics, &c. our business at present being only to explain the methods which have been employed to ascertain the nature and extent of the changes which it has been found to undergo. These changes chiefly refer to its *temperature*, *weight*, *moisture*, and *electricity;* and the instruments by which they are respectively measured, are the *thermometer*, *barometer*, *hygrometer*, and *electrometer*. The result of these changes is in some cases *wind*, and in others, *rain* or *snow*, which have also been subjected to measurement; the intensity of the former by the *anemometer*, and the quantity of the latter by the *pluvimeter*, or *rain-gage*. In describing the nature and application of these instruments, we shall endeavour to render our account intelligible to the general reader, from a conviction that a simple and popular view of their principles and use, is still a desideratum in works on meteorology. Many, we know, are prevented from taking an interest in the subject, from not understanding the nature or the application of the instruments to be employed; and if we can therefore in any degree contribute to the more extended use of these instruments, and consequently to the multiplication of meteorological observations, we shall consider our labours as of more service to the science in its present state, than the most ingenious theory, or the most profound speculations.

The *Thermometer* is an instrument employed for measuring the heat of bodies in general, and, among others, that of the atmosphere. It is a well-known fact, that all bodies are expanded, or have their bulk increased by heat, and are contracted or have their bulk diminished by cold, that is, when heat is abstracted from them. These variations of bulk are conceived to be proportional to the variations of heat, and it is upon this principle that the thermometer has been constructed. It consists of a glass tube AB (Plate CCCLXXIV. Fig. 1.) of a very small bore, having one extremity A blown into a bulb. This bulb and part of the tube or stem is filled with a liquid, generally mercury, which is found, on various accounts, to be of all others best fitted for the purpose. If the instrument in this state be applied to a body warmer than itself, the mercury will be seen to ascend in the tube; because the expansion of the glass being much less than that of the mercury, the bulb is no longer capable of containing the enlarged volume of the latter, which consequently rises into the empty part of the tube. In like manner, if the instrument be applied to a body colder than itself, the bulk of the mercury in the bulb being diminished, that portion of it which is in the tube will descend, to supply the diminution of volume; and this will be found to take place even when the tube is held in a horizontal position, the cohesion between the particles of mercury being such, as to admit of no separation of one portion of the mass from another. Hence it is obvious, that every change of temperature, that is, every increase or diminution of heat in the atmosphere, will produce, on a thermometer exposed to it, a corresponding expansion or contraction of the mercury; and it only remains, therefore, to find out some method of expressing the amount of these variations in such a way, as that the indications of one thermometer may be compared with those of another. This is accomplished by means of a graduated scale CD attached to the tube, the divisions of which are thus determined. It has been found that snow or ice in a melting state is always of the same temperature, and that the heat of boiling water, under the same pressure, is also uniform. These fixed points being determined, by immersing the instrument first in melting snow, and afterwards in boiling water, are transferred to the scale, and the distance between them is divided into a certain number of equal parts; the divisions being carried downwards below the melting, or, as it is improperly called, the freezing point, as far as is thought necessary, or as the scale will admit. Hence it is obvious, that two thermometers, having the freezing and boiling points thus determined, and the space between them divided into the same number of equal parts or degrees, must in similar circumstances uniformly indicate the same temperature. The divisions themselves will be larger or smaller, according to the relative capacities of the bulbs and stems, but this circumstance does not in any degree affect their indications. Neither is it necessary that the space between the freezing and boiling points should be divided into one number of parts rather than another. This is altogether arbitrary, and may consist of 50, 100, 1000, or any other that may be thought convenient. In comparing the indications of two thermometers, it is only requisite that the number in each be known, though it is certainly desirable that a uniform scale should be adopted.

According to the division generally used in this country, the space between the freezing and boiling points consists of 180 degrees. Fahrenheit, who first employed this scale, and whose name it still bears, imagined that the greatest cold that could be produced, is that which results from a mixture of snow and sea-salt, and he adopted that temperature as the commencement of the scale, which he accordingly marked zero, or *o*. He then exposed the instrument to the heat of boiling mercury, and having marked the point to which it rose, he divided the space between that point and the lower extremity into 600 equal parts. He afterwards found that the melting point of snow corresponded with the 32d division, and the boiling point of water with the 212th. Hence, in what are called Fahrenheit's thermometers, the freezing point is 32, and the boiling point 212, the difference between them being 180. The mode of graduating the scale originally adopted by Fahrenheit, has been long ago abandoned for that stated above; but the graduation itself, though liable to many objections, is still retained, and it is to this scale that all our references in this article are made. This graduation is represented on the side CD of the scale, in Fig. 1.

Among the various thermometrical scales that have at different times been proposed, that which is now generally used in France, and known by the name of the centigrade, is perhaps upon the whole the most eligible. The distance between the freezing and boiling points is divided into 100 equal parts, the freezing point being marked 0, and the boiling point 100. We must refer to our article THERMOMETER, for a particular account of the methods by which the indications of different thermometers may be compared; but we may here remark, that when any given temperature is expressed in degrees of the centigrade, it may be converted into those of Fahrenheit, by the following simple rule. Multiply the degrees of the centigrade by 9, divide the product by 5, and add 32 to the quotient. Thus when the centigrade stands at 25, Fahrenheit, in the same circumstances, will indicate 77, for 25 multiplied by 9, and divided by 5, gives 45, which added to 32 is 77. The divisions in every thermometer are numbered from zero downwards, in the same way as from zero upwards; but to distinguish them, the former are written with the negative sign or minus prefixed. Thus —15 means a temperature 15 degrees below 0. The degrees, according to this graduation, are represented on the side EF of the scale, in Fig. 1.

Thermometers are sometimes constructed of alcohol, or spirit of wine, which, though inferior in many respects to mercury, is on certain occasions preferable, and indeed necessary, as for example, in ascertaining temperatures below the point at which mercury freezes. In an alcohol thermometer, the freezing point may be ascertained by plunging it into melting snow, as stated above, but the other divisions must be determined by comparing it with a mercurial one, previously graduated as alcohol passes into a state of vapour long before it arrives at the heat of boiling water. Even mercurial thermometers are frequently graduated in this way, the tube in many of them being too short to admit of the instrument being exposed to so elevated a temperature.

In meteorological observations, it has been found very desirable to have some method of ascertaining the greatest degree of heat and cold, during any given interval, in the absence of the observer. Various contrivances have accordingly been employed for accomplishing this, by means of what are called self-registering thermometers. Those commonly in use are of a very simple construction. A mercurial thermometer, AB, (Plate CCCLXXIV. Fig. 2.) of a somewhat wider bore than ordinary, with a small bit of steel wire *a* over the mercury, so as to slide easily up and down in the tube, is placed in a horizontal position. As the temperature increases, the mercury pushes forward the bit of steel or index; but when the mercury again retires, in consequence of a diminution of temperature, the index remains behind at the highest point to which the mercury has risen. A thermometer AB (Fig. 3.) of a similar bore, but filled with spirit of wine, and having a small thread of glass *a*, about half an inch in length, immersed in the fluid, is also placed in a horizontal position. As the temperature diminishes, and the spirit sinks in the tube, it is found that the surface of the liquid does not pass the glass index, but carries it along with it, though, when an increase of temperature again takes place, and the spirit rises in the tube, the index is left behind at the lowest point to which the liquid had sunk. To prepare the instruments for a new observation, they are both inclined, so as to bring the index in each to the surface of the liquid, when they are again placed in a horizontal position. In referring to these instruments in the course of this article, we shall denominate the first a *maximum*, and the last a *minimum* thermometer. For a more particular account of the method of constructing these, and others of the same kind, see the article THERMOMETER.

In ascertaining the temperature of the atmosphere, by means of the thermometer, it is of great importance to attend to the situation of the instrument. It ought to be placed so as to be in the shade, not only at the time of observation, but during the whole day, and at such a distance from surrounding objects, as not to be affected by any changes in their temperature. We have repeatedly found that the reflection of the sun's rays from an opposite wall, though at the distance of 50 feet, and where there was a free circulation of air, has raised the thermometer several degrees higher than the actual temperature of the atmosphere. We have also found, that of two thermometers, graduated with the greatest care, and separated only by a thin bar of wood, the one on the upper side of the bar, from being more exposed to the sky than the other, has sometimes, during a clear night, stood several degrees lower. In meteorological observations, therefore, the thermometer should be screened from the sky, as well as from the reflection of the sun's rays. The bulb too should be exposed naked; and if it is accidentally wetted, it ought to be wiped dry before making an observation, otherwise it will indicate a lower temperature than it ought to do, from the influence of evaporation. In consequence of not attending to these sources of fallacy, we suspect that many of the meteorological tables that have been published, cannot be relied on as affording an accurate view of the temperature of the atmosphere.

The *Barometer*, we have already stated, is an instrument employed for measuring the changes that take place in the weight of the atmosphere. The principle upon which it is construeted may be explained by a very familiar example. If a tube, open at both ends, with a piston exactly fitted to it, have its lower extremity, to which the piston has been previously pushed down, immersed in water, on drawing up the piston, the water will follow it, and continue to do so till it rises to the height of about 33 feet. The same thing will take place if the tube be immersed in mercury, with this difference, that the mercury will ascend only to about the height of 30 inches. The effect in both cases is produced by the weight of the atmosphere. By drawing up the piston, the pressure of that weight is removed from the portion of the fluid immediately under it, while it continues to be exerted on the surface of all the rest. The liquid is therefore forced up into the tube, till the column be of such a height as to balance the weight of the atmosphere. If a glass tube of convenient length, and open at one end, be filled with mercury, and then inverted perpendicularly into a basin of mercury, so that the open end may be under the surface, the mercury will sink down from the upper extremity, and stand at the point to which it would have risen, had a piston been employed as stated above. In this form it constitutes a barometer, and the changes of weight which the atmosphere undergoes, are indicated by the rising and falling of the mercury in the tube. To measure these variations, a scale may be placed parallel with the tube, and divided into inches and decimals, beginning at the surface of the mercury in the basin. It is obvious, however, that if the scale be fixed when the mercury sinks in the tube, the surface of that in the basin must rise in proportion to the relative width of the basin and the tube, and consequently stand higher than the commencement of the scale; and in like manner, when the mercury rises in the tube, the surface of that in the basin must sink, and stand lower than the beginning of the scale. In the one case, therefore, the mercury in the tube will stand at a higher, and in the other at a lower point than it ought to do. This inaccuracy is in part removed, by making the basin very wide relatively to the tube, but still more effectually by constructing it in such a manner that the surface of the mercury in the basin may be raised or depressed to the commencement of the scale. In general a portion only of the scale is divided, viz. from the twenty-seventh to the thirty-first inch, reckoning from the surface of the mercury in the basin, because these are found to be the ordinary limits of the barometrical range. See Barometer.

It is hardly necessary to observe, that the barometer, in order to indicate correctly the weight of the atmosphere, should be placed in a perpendicular position. It should also have a thermometer attached to it, to be observed at the same time with the barometer itself, as the length of the column of mercury is affected not only by the pressure, but also, though in a much smaller degree, by the temperature of the atmosphere. Thus, if the barometer at the temperature of 32° stands at 30 inches, it would, under the same pressure at the temperature of 62°, stand at one tenth above 30 inches. The elevation of the place where the barometer is situated, is also necessary to be taken into the account. When carried upwards, the mercury is found to sink in the tube at the rate of about one-tenth of an inch for every 90 feet of ascent, (see Pneumatics) and consequently no comparison can be instituted, between observations of the barometer at different places, unless the heights of these places be accurately known.

Several plans have been proposed, and attempts made, to construct a self-registering barometer, for recording the greatest elevations and depressions of the mercury, in the absence of the observer. The contrivances are abundantly simple, but they are all liable to the same objection, that by increasing the friction, they diminish the delicacy of the instrument, thereby rendering it unfit for indicating minute changes in the pressure of the atmosphere. The simplest, and perhaps the best contrivance of this sort hitherto proposed, is described in our article Barometer. For representations of different forms of the barometer, see Plates LIII. and LIV.

An improved portable barometer, or rather a substitute for that instrument, has lately been invented by Mr. Adie of this place, which we shall shortly describe in the words of the inventor himself, as stated in the patent. The principle of the instrument, which Mr. Adie has denominated a *Sympiesometer*, consists in measuring the weight of the atmosphere by the compression of a gaseous column. It consists of a tube of glass ABCD, (Plate CCCLXXIV. Fig. 4.) of about 18 inches long, and 0.7 of an inch diameter inside, terminated above by a bulb D, and having the lower extremity bent upward, and expanding into an oval cistern A, open at top. The bulb D at the upper extremity being filled with hydrogen gas, and a part of the cistern A and tube BC with almond oil, coloured with anchusa root, the enclosed gas, by changing its bulk according to the pressure of the atmosphere on the oil in the cistern, produces a corresponding elevation or depression of the oil in the tube, thereby indicating the variations in the weight of the atmosphere. The scale for measuring these changes is determined by placing the instrument along with an accurate barometer and thermometer, in an apparatus where the air may be condensed or rarified, so as to make the barometer stand at 27, 28, 29, 30, or any other given number of inches. The different heights of the oil in the tube of the sympiesometer corresponding to these points being marked on its scale EF, and the spaces between being divided into an hundred parts, these divisions correspond with hundredths of an inch, on the scale of the mercurial barometer. To correct the error that would arise from the change produced in the gas by a change of temperature, the principal scale EF is made to slide upon another GH, so graduated, as to represent that change, and corresponding to the degrees of a common thermometer IK attached to the instrument. In this state, the rule for using the instrument is simply to observe the temperature by the thermometer, and to set the index *a* which is upon the sliding scale, opposite to the degree of temperature upon the fixed scale, then the height of the oil, as indicated on the sliding scale, will be the pressure of the air required. The sliding scale EF is moved by means of the knob L. We shall have occasion in another part of this article to notice the indications of the sympiesometer, as compared with those of the common barometer. See the *Edinburgh Philosophical Journal*, vol. i. p. 54.

The *Hygrometer* is an instrument of great importance in meteorology, as indicating changes in the humidity of the atmosphere. The idea of this instrument seems to have been first suggested by the expansions and contractions, which animal and vegetable substances are observed to undergo, when exposed to different degrees of moisture. We find accordingly that a great proportion of the hygrometers hitherto employed, have consisted of one or other of these substances, and though some of them are susceptible of great delicacy, they are all radically defective, inasmuch as the frequent changes to which they are exposed must in time produce a partial derangement in the texture of the substances, and consequently their indications become inaccurate. The only hygrometer that we think deserving the attention of meteorologists, is that delicate instrument the thermoscope of Count Rumford, or the differential thermometer of Mr. Leslie. This instrument has already been described, and its superiority to every other pointed out, in the article Hygrometry, to which we refer.* We apprehend, however, that it is not yet so perfect as to be incapable of farther improvement, and we have therefore to propose a modification of it, which we conceive is better adapted to the purposes of meteorology. In the course

* Our countryman, Dr. James Hutton, as we are informed by Mr. Playfair, was the first person who applied the power of evaporation to produce cold, to the construction of a Hygrometer, and was, therefore, the undoubted inventor of the *Thermometrical Hygrometer.* Mr. Leslie substituted, in place of the common thermometer, the *Thermoscope*, or differential Thermometer, invented by Count Rumford and himself. See Playfair's *Life of Hutton. Edin. Trans.* Vol. V. p. 67, note. Ed.

of our observations, we had long felt that a self-registering hygrometer was still a desideratum; and though it readily occurred to us that the differential thermometer might easily be constructed, so as to mark the greatest dryness in the absence of the observer, there appeared to be some difficulty in making it to register the greatest moisture. Both these objects are completely accomplished by the following simple contrivance, which, as far as we know, is the first attempt of the kind that has hitherto been made. We have already submitted it to the public through the medium of Blackwood's Magazine.(No. 12.) though we do not know that it has yet been adopted in any meteorological observations.

A tube, CD (Plate CCCLXXIV. Fig. 5.) such as is commonly used for constructing a self-registering thermometer, is bent upwards at C and D, and terminates in a bulb A. Into this bulb is introduced a portion of sulphuric acid, sufficient to fill the tube and a small part of the bulb; and along with the acid a small bit of glass *a*, of such a diameter as to move easily in the tube when the instrument is inverted. To the extremity D another bulb B is attached; and the air contained in both bulbs is so adjusted, that when they are at the same temperature the liquid stands at a point near the extremity D, and which is marked 0 on the attached scale EF. If the temperature of the bulb B be now increased, or, which produces the same effect, if that of A be diminished, the portion of air in the upper part of the bulb will contract, while that contained in B will expand in the same proportion, and the liquid will of course be forced from D towards C, the difference of temperature being indicated upon the scale in degrees, each of which, according to the graduation adopted by Mr. Leslie, is the thousandth part of the difference between the temperatures of freezing and boiling water. The divisions of this scale, which has been called the *millesimal*, may be thus determined: Let the bulb A be surrounded with melting snow, while the instrument is placed in an atmosphere of any higher temperature, say 50° of Fahrenheit, and let the point be marked at which the liquid becomes stationary. The distance between zero and this point, in the case supposed, will be 18° of Fahrenheit, or 100° of the millesimal scale, and that distance being divided into an hundred equal parts, will give the graduation required. The divisions may be extended beyond 100° if necessary, but in this climate a greater range will seldom be required.

To prepare the instrument for observation, it only remains to cover the bulb A with silk, and moisten it, taking care that the two bulbs be as nearly as possible of the same colour. The index, or small bit of glass *a*, is then to to be brought to the surface of the liquid, by depressing the extremity D, and the instrument to be exposed in a horizontal position. As the evaporation from the surface of the bulb A goes on, the air within contracts, from the depression of temperature produced by the evaporation; and the liquid is forced from D towards C by the elasticity of the air in B, carrying with it the index *a*. When the evaporation has reached its maximum, the liquid as well as the index becomes stationary; but should the process of evaporation diminish, the liquid will again move towards D, while the index is left behind, thus marking the *maximum of dryness in the absence of the observer.*

To find the greatest degree of moisture, another instrument is to be employed, which is represented in Plate CCCLXXIV. Fig. 6. The only difference between this and the former is, that the air in the two bulbs is to be so adjusted, that when they are at the same temperature the liquid may stand near the extremity C, the distance between C and zero being a little more than the length of the index *a*, and the bulb B is to be covered as A was in the former. The scale is graduated as before.

When the instrument is adjusted and exposed, evaporation goes on from the surface of B, and the liquid of course moves towards D; but when the evaporation diminishes, the liquid is again forced back towards C till it arrives at the index *a*, and should the evaporating energy, or dryness of the air, still continue to diminish, the index itself is then carried towards zero till the evaporation be at its minimum. The liquid then becomes stationary; and though it should afterwards mount higher, in consequence of an increased evaporation, still the index remains at the lowest point to which the liquid had sunk, thus marking *the minimum of dryness in the absence of the observer.* In both cases, as in the original form of the hygrometer, the covered bulb is to be kept continually moist with water, conveyed to it by filaments of floss silk from an adjoining vessel. We shall afterwards have occasion to notice the advantages of the above form of the hygrometer.

In our meteorological observations, we have been accustomed for several years to employ two delicate thermometers instead of a hygrometer, and find that they not only answer the same purpose, but have the additional advantage of showing the absolute as well as the relative temperatures of the two bulbs. The thermometers are of such a range as to admit reading off the tenth of a centigrade degree, which corresponds with a degree of Leslie's scale. The bulb of one of them is covered with silk kept constantly moist, and the difference of temperature between the two, expressed in tenths of a centigrade degree, gives the height of the hygrometer by the millesimal scale.

Of the *Electrometer* as a meteorological instrument, it is unnecessary to say much. It has never yet been regularly observed, except for a limited period, nor is it likely to be so soon. Our readers will find a full account of the various electrometers at present known under the article ELECTRICITY, with the results of observations made by some of the most delicate of these instruments. The difficulty of construction, as well as the want of a determinate scale by which to measure the intensity of atmospherical electricity, presents an obstacle to the general use of the electrometer, which we are afraid will not soon be surmounted, though the discovery of such an instrument on simple and accurate principles, could hardly fail greatly to extend the boundaries of meteorological science. That science indeed must always be in an imperfect state, so long as we have not the means of measuring the effects of the most active of all agents in the production of atmospherical phenomena.

The only other instruments connected with meteorology which we shall at present notice, are the *Anemometer*, *Rain-gage*, and *Atmometer*. The anemometer, or instrument for measuring the velocity of the wind, has already been treated of under that article, where its various forms have been fully described. Of these, Lind's is perhaps the most convenient, though Leslie's is unquestionably the most philosophical. The former measures the force of the wind by the height to which it raises a column of water in a bent tube, as indicated by an attached scale. A table shewing the velocity of the wind, corresponding to various heights in the column, is given at the end of the article Anemometer, from which it appears, that when the velocity does not exceed six miles an hour, the elevation of the water is so small as to render it impossible to ascertain the precise height of the column without the help of a vernier, a contrivance of which the nature of the instrument hardly admits. We have found, indeed, from experience, that it is quite impracticable with this instrument to determine the velocity of the wind with any thing like accuracy, unless it amounts to about 11 miles an hour, or what Lind calls a fresh breeze.

Leslie's anemometer is founded on the principle, that the cooling power of a stream of air is proportional to its velocity. It consists simply of a common spirit of wine thermometer having a pretty large bulb; and the force of the wind is deduced by an easy calculation, (see Anemometer,) from the time which it takes to cool through half the number of degrees which it had been previously raised by the heat of the hand. The result thus obtained, we have found in a great many instances to coincide almost exactly with that given by Lind, according to Hutton's calculations; the coincidence being always closest when the wind was so high as to admit of Lind's anemometer being accurately observed. It is to be regretted that the instrument has hitherto been so seldom used.

The *Pluvimeter*, or rain-gage, for ascertaining the depth of rain that falls on any given spot, is variously fitted up; but we shall confine ourselves to the description of one which we have used for many years, and which appears to us as simple, and at the same time as accurate, as any that we have yet seen. It consists of a copper funnel AB, (Plate CCCLXXIV. Fig. 7,) five inches in diameter at top, and inserted into a tube CD of the same metal, thirty inches in length, and one and a half in diameter, furnished with a stop cock E at the lower end. It is examined every morning at ten o'clock, and if any rain has fallen during the preceding 24 hours, it is measured by letting it off through the stop-cock into FG, a glass tube of .5 of an inch in diameter, with an attached scale of inches and tenths. By this means the rain that falls on a circular area of 5 inches in diameter is collected on an area of .5 of an inch, so that inches and tenths of water in the tube correspond to hundreths and thousandths of an inch of rain on the surface of the ground.

To prevent waste by evaporation, the communication between the funnel and the copper tube is made very narrow. The upper edge, or rim of the funnel, is also turned upwards from the inclined direction of the under part, so as to stand perpendicular, the better to prevent the rain that falls within the gage from being thrown over after striking against the interior. In some rain-gages, the rim is inclined a little from the perpendicular inwards. This we conceive to be wrong, as part of the rain that falls on the outside of the inclined rim may thus be thrown into the gage, which will consequently indicate a greater quantity than it ought to do. After all, however, the rain-gage is but an imperfect instrument. It gives only an approximation to the depth of rain in any case, and of small quantities it gives no indication at all, owing to the loss by evaporation before passing from the funnel into the tube. It is hardly necessary to remark, that the upper edge of the funnel ought to be parallel to the horizon, and that the instrument should be placed at a distance from any object that might screen it from the rain.

The *Atmometer*, or as it is sometimes called the *evaporometer*, for measuring the quantity of water evaporated in any given time, is an instrument which has not till lately been brought to any great degree of perfection. A circular basin of uniform width from top to bottom, filled with water, is the simplest form of the instrument; and the quantity evaporated may be very accurately ascertained by means of a graduated glass tube, similar to that described above for measuring the depth of rain. There are several difficulties, however, attending the use of the instrument, which render it a very uncertain indication of the absolute quantity evaporated. If it be exposed freely to the sun and wind, the heat acquired by the vessel itself will rapidly promote evaporation; and if the basin be kept nearly full, as it ought to be, the water will be agitated, and thrown over by the wind. Nor do we conceive, even though this last accident were guarded against, that the result would be either satisfactory or important. If the object of the atmometer be to ascertain the dissolving power of the air, it may be accomplished by placing the basin in a sheltered situation as well as if it were freely exposed, and if the quantity evaporated from the ground be required, the simplest and the most accurate method is that adopted by Dalton, as explained under the article Evaporation.

An atmometer, upon a very simple principle, was some years ago constructed by Mr. Leslie. It consists of a ball of porous earthenware two or three inches in diameter, into which is inserted a glass tube, so graduated that the quantity of water contained between two divisions of the tube, would cover the outer surface of the ball to the depth of one thousandth part of an inch. The ball and tube being filled with water, the top of the latter is covered with a brass cap, which by means of a screw and collar of leather is made quite air-tight, and the instrument is suspended out of doors, freely exposed to the wind. In this state the humidity exudes through the surface of the ball just as fast as it evaporates, and the descent of the column in the tube indicates the quantity evaporated. As the pressure of the atmosphere is, in a great measure, removed by the tightness of the collar, the water is prevented from passing through the ball so quickly as to drop, while the space which it leaves empty at the top is occupied by the very minute stream of air which is imbibed by the moisture on the outside, and may be seen rising through the water in the tube.

The instrument is very simple, but we have found, from numerous trials, that it is totally useless for a continued series of observations. The obvious impossibility of using it in frosty weather is itself an insuperable objection; but there is another which renders it equally unsatisfactory at all seasons of the year. Though a portion of air, as we have already remarked, is imbibed by the humid surface of the ball, and rises into the part of the tube from which the water has subsided, it is in so small a quantity as to exert very little pressure on the surface of the water. The consequence is, that during a shower, the rain that falls on the surface of the ball is forced into the interior, so that the water again rises in the tube; and though the elasticity of the air above must at length counteract this process, it is still sufficient to render the indications of the instrument altogether uncertain. As a proof of this, we shall mention one instance among several others that might be stated. On an evening of a dry summer day the water in the tube of the atmometer stood at 100°. During the night there was a heavy fall of rain, and next morning the surface of the liquid was as high as 15°. This fact, we apprehend, is decisive as to the merits of the instrument. Mr. Leslie has shewn, in his treatise on the relations of air to heat and moisture, that it may be successfully applied to various important purposes in the arts, and in certain circumstances to meteorological researches; but it is totally unfit for measuring the quantity of evaporation during an interval of any considerable length.

Since writing the above, we have received from the friend to whose hygrometrical researches we shall frequently have occasion to refer in the course of this article, a description of an Atmometer which he has lately invented, and which is undoubtedly the simplest as well as the most ingenious instrument of the kind hitherto proposed. It consists of a bent glass tube, ABCDEF, (Plate CCCLXXIV. Fig. 8.) of sufficient width to admit of a liquid moving easily from one part to another, and swelling out into the bulbs BC and EF. Into this tube at A is introduced a quantity of alcohol, which, after being conveyed into the bulb or wider tube EF, is thrown into a state of ebullition, and while the steam is issuing from A, the tube is there hermetically sealed, so that the air is completely expelled from the space ABCDE. The bulb BC is then covered with moistened silk or paper, and the instrument freely exposed. In consequence of the pressure of the air being removed from the surface of the alcohol in the bulb EF, a portion of that liquid passes into vapour, and occupies the empty part of the tube. Were the whole of the instrument at the same temperature, this process indeed would quickly be stopt by the pressure of the vapour itself on the surface of the alcohol; but as the bulb BC has its temperature reduced by the external evaporation from the moistened silk or paper, the vapour which rises from EF is there condensed, and runs down in a liquid state into the tube AB. This distillation goes on more or less rapidly, according to the degree of cold induced upon the bulb BC; that is, in proportion to the external evaporation; and, consequently, the quantity of liquid collected in the tube AB is a measure of that evaporation. When the atmosphere is completely saturated with moisture, or when the evaporation ceases, the temperature of AB will be the same as that of any other part of the tube, and the distillation therefore, for the reason already stated, will also cease.

The measure of evaporation thus found is expressed in inches, and decimals of an inch, by means of an attached scale GH, the divisions of which are determined by experiment. Suppose, for example, that the instrument is exposed in similar circumstances with an evaporating basin, and that the quantity evaporated from the latter in a given time, as determined either by weight or measurement, is found to be one-tenth of an inch, while the alcohol distilled by the former in the same time, fills the tube AB to the depth of one inch; then the scale being divided into inches and tenths, will indicate tenths and hundredths of an inch of evaporation. By increasing the proportion between the diameters of EF and AB, the quantity of evaporation may be measured to any degree of minuteness required. In using the instrument, the tube EF is to be sheltered from rain by enclosing it in a case or cover, to prevent its temperature being reduced below that of the atmosphere by subsequent evaporation, and the bulb BC is to be kept constantly moist by means of a small cup containing water attached to the tube immediately below it, the silk or paper being in contact with the water, or from an adjoining vessel, as in the case of the hygrometer. The instrument is placed in a vertical position, and is prepared for a new observation by inverting it, so that the distilled alcohol may be conveyed back to the tube EF. It is to be hoped that this beautiful and ingenious contrivance will soon meet with that reception among meteorologists, to which its merits so well entitle it. The instrument has already been constructed, and is found to possess the utmost delicacy. It is probable that it may, in time, supersede the use even of the hygrometer.

Application of Meteorological Instruments.

In considering the application of meteorological instruments, and the discoveries to which they have led, we shall follow the same order that we have observed in explaining their nature and principles. The first object of inquiry, indeed, and one which of all others has engaged the attention of philosophers, is the method of determining the average or mean temperature of the atmosphere at any given place. The solution of this problem is sufficiently interesting in itself, but it has become still more so from the other important questions which it involves. It is intimately connected with the determination of the law that regulates the distribution of heat over different climates, and it is only by accurately ascertaining the mean temperature of a place at different and distant periods, that we can ever hope to solve the question which has been so much agitated of late, whether the temperature of this country, or of the globe in general, is increasing, stationary, or diminishing. We shall, therefore, consider the subject at as great length as our limits will permit.

The most accurate method of ascertaining the mean temperature of any place, is to note the thermometer at the end of every indefinitely short interval, add all the temperatures together, and divide the amount by the number of observations. The quotient will give the average or mean temperature for the day, month, year, or any other period during which the observations were continued, and the shorter the intervals, the more accurate will be the result. This method, however, being for obvious reasons impracticable, various expedients have been proposed for approximating to the mean by a less laborious induction of facts. Indeed, the necessity of limiting the number of observations to two or three in the course of twenty-four hours, has been almost universally admitted; for however desirable it might be to have them taken more frequently, few are found to possess either leisure or patience for doing so. This remark must be understood as applying only to the thermometers that have hitherto been employed, for it is possible that a method may yet be discovered of finding the true mean temparature of any given interval, with the greatest precision. Such a method indeed has actually been proposed by Dr Brewster, by means of an instrument which he denominates an ATMOSPHERICAL CLOCK, and of which a short account will be found under that article. It was again noticed under the article BAROMETER, to which, as well as to the hygrometer, the principle is equally applicable. From the friction that must necessarily take place in such an instrument, the extremes might not perhaps be recorded with the same accuracy as by a delicate self-registering thermometer; but there seems to be no reason to doubt, that it would give the average of all the changes of temperature, pressure and moisture, with the greatest accuracy. As the Atmospherical Clock, however, has not yet been generally used, we must still inquire how the problem in question may be most accurately solved by the instruments described in the preceding part of this article. The only question therefore at present is, at what hours of the day and night ought the observations of the thermometer to be made, so as to give the nearest possible approximation to the mean temperature of the whole twenty-four hours.

For a considerable time after the thermometer came into general use, little attention seems to have been paid to the hours of observation, nor are they very rigidly adhered to, even by meteorologists of the present day. It is no uncommon thing to see in registers the state of the thermometer, morning and evening, without specifying at what hour of either the observation was made; or when the time is mentioned, to find it an hour earlier or later one day than another. Such registers may serve to gratify the curiosity of the individuals who keep them, but it is obvious they can add little to our stock of meteorological knowledge. Their results may accidentally approach to the mean temperatures of the places where they are respectively observed, but we have no certainty of their doing so, and in as far as they have hitherto been employed as data on which to found any theory whatever, they are worse than useless.

But the same objections are in part applicable, we suspect, to not a few even of those registers in which the observations have been uniformly made at certain hours of the day. In some we find the hours of observation six in the morning and noon, in others eight in the morning and two in the afternoon, in others nine in the morning and three in the afternoon, according to the convenience or particular opinions of the observers. In short, we seldom find two registers kept at the same hours, nor are the number of observations always the same. By some, one is considered as sufficient, provided it be made at the hour when, according to their theory, the temperature of the day is about its mean, while others observe two, three, or even four times, during the twenty-four hours. Now, without pretending to decide on the merits of the various hours of observation, or to determine which of them are most likely to give the nearest approximation to the true mean temperature, it must be obvious to every body, who is in the least degree acquainted with the fluctuations that are perpetually taking place in the temperature of the atmosphere, that such registers can admit of no comparison with one another. They may afford a tolerably accurate view of the relative characters of different years, at the respective places of observation; but unless it can be shown that their results approach all equally near to the true mean, they furnish no assistance that can be relied on, towards the solution of the important meteorological question, What is the difference between the mean temperatures of two places on the surface of the globe?

It might naturally have been expected, that after the invention of the self-registering thermometer, these differences in meteorological registers would have disappeared, and that whatever opinions individuals might entertain, as to the best hours for observing the actual state of the thermometer, they would at least record the maximum and minimum temperatures of every twenty-four hours. This, indeed, has in many cases been done, and has already contributed not a little to give a precision and accuracy to the subject which it did not before possess. Still, however, the use of these instruments has been more limited, and the results of their indications less attended to, than could have been wished. There seems to be a propensity too, among certain philosophers, to undervalue these results, arising perhaps from the difficulty which they find in reconciling them with certain preconceived notions and favourite theories of their own. It may be worth while therefore to inquire, upon what principle the mean of any two observations can be considered as a nearer approximation to the true mean of the twenty-four hours, than that of the maximum and minimum of the same period.

We cannot indeed pretend to demonstrate, that the mean temperature of any two or three given hours does not coincide with or approach very near to the true mean of the whole day and night; but it must be obvious, we think, that their agreement can be known only when the latter has been otherwise and accurately determined. Suppose, for example, that the mean temperature at any two hours, as eight in the morning and two in the afternoon, has been found by regular observations continued for a series of years to be 50°, what grounds have we to conclude that 50 is the true mean temperature of that place, unless it was previously known to be so, or without assuming as found, the very point which the observations themselves are intended to discover? It is not enough that we can assign plausible reasons of a theoretical nature, for supposing that it must be either exactly or nearly the true mean. The whole is a matter of experiment; and though we may have determined with the utmost precision what is the mean temperature of any given hour or hours, it still remains to be proved whether that agrees or disagrees with the true mean temperature of the day. We are disposed, therefore, to place very little faith in many of the opinions that are advanced, and the sweeping conclusions that are drawn, on this interesting subject. We have been lately told, for example, on the authority of Humboldt, that the mean, or half the sum of the maximum and minimum observed during the day and night, or through the summer and winter, does not represent the true mean temperature—and that between the parallels of 46° and 48°, the thermometer at sunset indicates nearly the medium temperature of the day. Now, in all this, it is obviously taken for granted, that the true mean temperature had been accurately ascertained by means independent both of the maximum and minimum, and of the temperature at sunset; and the question, therefore, still recurs, how was it determined?

As we have not had an opportunity of examining the original paper, in which this opinion is said to be advanced, we cannot give the solution of the question in Humboldt's own words; but if the abridgment of it given in Thomson's Annals can be depended on, it appears that the principle on which that opinion rests is merely a gratuitous assumption. The words of the abridger are these: "By comparing a great number of observations made between 46° and 48°, N. latitude, we find that at the hour of sunset the temperature is very nearly the mean *of that at sunrise and two hours after noon*." The amount, therefore, of Humboldt's discovery is simply this: That the temperature at sunset agrees more nearly with the mean of sunrise and two hours after noon, than it does with the mean of the maximum and minimum observed during the day and night; but it does not necessarily follow that it agrees with the true mean temperature of the day. It seems doubtful indeed whether Humboldt ever intended to draw any such conclusion. In the paper already alluded to, the reason assigned for making observations at sunrise and two hours after noon is, that the temperatures at these hours are considered as indicating the maximum and minimum. It is also stated, that if, besides the maximum and minimum, a middle observation be taken, it should be at least four or five hours from either of the others; but that, upon the whole, *the two observations of the extreme temperatures will give us more correct results.* It is to the daily extremes, therefore, that Humboldt ultimately appeals, as the standard by which to judge how near the temperature of any other hour approaches to the true mean, and if he has recommended any fixed period for making a single observation, it is rather with a view, we suspect, of abridging the labour, than of affording a more correct result. Such an abridgment is certainly desirable, but we are disposed to doubt whether it is at present attainable in the case of meteorological observations. The science is still in a condition that requires a copious induction of facts; and there is reason, therefore, to apprehend, that in proportion as we diminish the number of observations, we sacrifice accuracy to simplicity, and substitute theory for experiment.

Our readers will perceive, from these remarks, that we are inclined to consider the mean of the daily extremes, as approaching nearer than that of any other observations, to the true mean temperature of any given place; and the grounds of this opinion appear to us exceedingly simple and obvious. Were the actual temperature observed at very short intervals, say every half hour during the day and night, through the whole year, the mean of all the observations would undoubtedly give a very near approximation to the true annual mean; but it would obviously be still nearer, if, instead of these, the extremes of every hour were marked, and half their sum taken as the mean of the hour. The former method, indeed, would be equally accurate, did the temperature of the atmosphere suffer no interruption in its progress from one extreme to the other; but, liable as it is to frequent fluctuations, the most probable method of approximating to a correct estimate of these is, to note the extremes at short intervals. The same reasoning will apply, in some degree, to intervals of a greater length, though it may naturally be supposed, that, in proportion as these are extended, the result will be less accurate. We have found, however, from actual observation, that the difference between the means of the extreme temperatures, taken at shorter and longer intervals, is much less than at first sight we should have been led to expect, as will appear by the following results, deduced from our observations for 1817 and 1818.

	1817.	1818.
Mean of the 2 annual extremes . .	45.5	48.5
Mean of the 12 monthly extremes . .	45.4	47.5
Mean of the 36 extremes for each 10 days	45.4	47.4
Mean of the 365 daily extremes . .	46.1	47.2

These results, we think, furnish satisfactory evidence that the mean temperature derived from observing the daily extremes, cannot be far from coinciding with the true mean of the whole year; but even granting that it were otherwise, there are still arguments enough to demonstrate that these extremes ought to be recorded, in preference to any other observations. In determining the law which regulates the distribution of heat over the globe, we must be guided entirely by experiment. Calculations of the quantity of heat which is communicated to the earth in a given time, by the direct action of the sun's rays, or of the effects produced by the constant interchange of warmer and colder portions of the atmosphere, between one region and another, may be sufficiently amusing; but we shall look in vain to such calculations for the discovery of a law, which, as we have every reason to believe, is affected by so many disturbing causes, and modified by such a variety of circumstances. The combined effects of all these can be discovered only by collecting the results of observations in various situations, and under different latitudes. Nor is it enough that these observations have been carefully and regularly made. Before they can be employed as the foundation of any theory, it must be ascertained that they were made under similar circumstances. To compare the mean temperatures of two different places, which have been deduced from observations made at different hours, is to compare quantities that do not admit of comparison, and which, for any thing we know, may bear very different relations to the true means of these places. Now, the great advantage of recording, in all cases, the maximum and minimum of the day and night, would be, that every meteorological register would speak the same language, and put us in possession of the same physical fact. Even if they did not give us the true mean temperatures of the respective places where they are kept, (though, as we have already seen, their results would approximate to these quantities,) still the term mean temperature, which at present is used by every observer to denote the annual average of his observations, at whatever hours they may have been made, would have a definite and distinct meaning, expressing, in all cases, the middle point of the thermometrical range during certain periods. Till some such uniformity be established among meteorologists, the multiplication of registers will serve but little to extend the boundaries of this branch of science.

For the reasons now stated, we are not disposed to place so much confidence as many have done in the theorem given by Mayer, for determining the mean temperature of any given latitude at the level of the sea. We do not indeed quarrel with it because it is avowedly empirical, for it is only from experiment that any satisfactory rule on the subject can be deduced; but we entertain very considerable doubts as to the accuracy of the observations on which it is founded. We have already seen that, from the diversity of opinion that still exists respecting the best time for observing the temperature of the atmosphere, many of our meteorological registers are comparatively of little use; and we have no reason to suppose, that, previous to the middle of the last century, they were kept on a more accurate principle. The theorem, however, is valuable, as affording, by a very simple process, a general view of the diminution of temperature from the Equator towards the Pole; and though, in its present form imperfect, as we shall afterwards show, it may, by future corrections, become in time more accurate, as well as more extensively applicable.

The formula, as stated by Mr. Playfair in his Outlines of Natural Philosophy, is as follows. Let L be the latitude of the place whose temperature t is required, M the mean temperature of the parallel of 45°, and M+E the mean temperature of the Equator, then

$$t = M + E \cos. 2 L.$$

According to the observations collected by Mayer, M=58°, M+E=85°, and consequently E=27°. By substituting these numbers, the formula becomes

$$t = 58 + 27 \times \cos. 2 L.$$

When the latitude exceeds 45°, 2 L is greater than 90°, so that cos. 2 L becomes negative, or t is less than 58° The formula may be thus expressed at length. Multiply the cosine of twice the given latitude by 27, and add the product to 58; the sum will be the mean temperature of that latitude at the level of the sea. By this formula we have calculated the following table, showing the mean temperature for every parallel of latitude from the Equator to the Pole, expressed in degrees of Fahrenheit's thermometer. The table, strictly speaking, belongs to the subject of climate, which will be considered at greater length under the article Physical *Geography*; but as it is also intimately connected with the method of ascertaining the mean temperature, and as we shall have occasion hereafter to refer to it, in the course of this article, we have thought proper to introduce it here.

Lat.	Mean temp. at the level of the sea.	Lat.	Mean temp. at the level of the sea.	Lat.	Mean temp. at the level of the sea.
1	85.0	31	70.7	61	43.7
2	84.9	32	69.8	62	42.9
3	84.8	33	69.0	63	42.1
4	84.7	34	68.1	64	41.3
5	84.6	35	67.2	65	40.6
6	84.4	36	66.3	66	39.9
7	84.2	37	65.4	67	39.2
8	84.0	38	64.5	68	38.6
9	83.7	39	63.6	69	37.9
10	83.4	40	62.7	70	37.3
11	83.0	41	61.8	71	36.7
12	82.7	42	60.8	72	36.2
13	82.3	43	59.9	73	35.6
14	81.8	44	58.9	74	35.1
15	81.4	45	58.0	75	34.6
16	80.9	46	57.1	76	34.2
17	80.4	47	56.1	77	33.7
18	79.8	48	55.2	78	33.3
19	79.3	49	54.2	79	33.0
20	78.7	50	53.3	80	32.6
21	78.1	51	52.4	81	32.3
22	77.4	52	51.5	82	32.0
23	76.8	53	50.6	83	31.8
24	76.1	54	49.7	84	31.6
25	75.4	55	48.8	85	31.4
26	74.6	56	47.9	86	31.3
27	73.9	57	47.0	87	31.2
28	73.1	58	46.2	88	31.1
29	72.3	59	45.3	89	31.0
30	71.5	60	44.5	90	31.0

Mr. Leslie, in his *Elements of Geometry*, has expressed the above formula somewhat differently, and the results which he has deduced from it are also different. He assumes the mean temperature of the equator to be 29° centigrade, or 84°.2 Fahrenheit, and the mean of the pole comes out 32°. In all latitudes between the equator and the parallel of 45°, the mean temperatures in Mr. Leslie's Table are rather less than those in the above, and for higher latitudes somewhat greater. It appears, however, that the modification of the formula which he has employed, does not agree so well with the latest observations, as the original expression of Mayer, except in one case, where Mr. Leslie himself has applied it; nor do we find any satisfactory evidence in support of his opinion, that the law, as he has modified it, connects most harmoniously the various results of observations made at distant points on the surface of the globe. So far from this being the case generally, we can find nothing like harmony between the results of the Table and actual observations, even in that portion of the globe to which philosophers, previous to Mr. Leslie's extension of the law, considered the formula as applicable, viz. between the parallels of Stockholm and the Cape of Good Hope, and from the meridian of Stockholm westward to the coast of America. In proof of this, we shall extract from the meteorological observations collected by Humboldt for the purpose of determining the isothermal lines, or lines of equal temperature on the globe, the mean temperatures of a few places at the level of the sea, and compare them with the standard temperature as given by Mayer and Leslie, confining ourselves to such as were determined with the greatest precision, and from the greatest number of observations.

Place.	Latitude.	Temperat. accord. to Humboldt.	Temperat. according to Mayer.	Temperat. according to Leslie.
Ulea . .	65.° 3'	33.°0	40.°6	41.°3
Umea . .	63. 50	33. 2	41. 6	42. 3
Petersburgh	59. 56	38. 8	44. 5	45. 0
Upsal . .	59. 51	42. 0	44. 8	45. 3
Stockholm	59. 20	42. 2	45. 1	45. 6
Copenhagen	55. 41	45. 6	48. 2	48. 6
Kendal . .	54. 17	46. 2	49. 4	49. 7
Prague . .	50. 5	49. 4	53. 3	53. 6
Edinburgh	55. 57	47. 8	47. 9	48. 3
London . .	51. 31	50. 4	52. 0	52. 3
Rome . .	41. 53	60. 4	60. 9	60. 9

The only instances in the above Table, where there is any thing like a coincidence between the result of observation and Mr. Leslie's formula, are those of Edinburgh and Rome, where the difference is exactly half a degree; but it would surely be a very unwarranted stretch in the adaptation of facts to theory, to set up two or three instances of agreement against so many and such glaring discrepances as the Table exhibits. The mean temperature of Edinburgh is said to be deduced from *six* years observations by Mr. Playfair. We suspect there is an error in this statement, as 47.8 is the mean of *three* years observations, viz. 1797, 1798, and 1799, as given by Mr. Playfair in the *Philosophical Transactions*. But however this may be, we are still disposed to regard the coincidence in this case, rather as accidental, than as affording any satisfactory evidence of the accuracy of the formula. The observations were made by Mr. Playfair three times a day, viz. at eight in the morning, one or two in the afternoon, and ten at night. Now, though it is impossible, from the well-known character of that eminent philosopher, to doubt the accuracy of Mr. Playfair's observations, still it is an assumption which is yet to be proved, that the mean temperature of these hours is the true mean temperature of the day; and even if this were proved, the error of half a degree is much too great to admit the application which has been made of the formula. According to our own observations, the mean temperature comes out considerably lower than that given by the rule, so that the difference seems in all cases to be on the same side, at least in latitudes above 41. At Kinfauns Castle, the seat of the Right Hon. Lord Gray, latitude 56° 24′, the mean of the daily extremes, for six years, from 1813 to 1818 inclusive, is 46°.3; and making allowance for the elevation of the place, (130 feet) 46°7. By Mayer's formula, it ought to be 47 7, and by Leslie's 48.1. The mean temperature of another place, under the same latitude, but more elevated and less sheltered, deduced from the daily extremes for five years, from 1814 to 1818, is 45°.7, and making allowance for the elevation 46°.2, which differs still more than the former from the result of the formula.

Another method, and perhaps the most correct of any, of determining the mean temperature of any given latitude, is by observing copious and well shaded springs. There can be little doubt that the mean temperature of the ground must, upon the whole, coincide very nearly with that of the atmosphere, from the well known tendency of heat to diffuse itself, so as to establish an equilibrium in temperature between two contiguous bodies. Every fluctuation of heat and cold at the surface will be communicated to the interior, more or less quickly according to circumstances, till the whole mass acquires the same temperature, while those fluctuations must obviously become less sensible in proportion to the depth below the surface. We are thus led to expect, that beyond a certain depth the temperature becomes stationary at or very near the mean temperature of the latitude; and the advantage of observing the temperature of a copious spring is, that at all times it will give an approximation to this quantity. At the same time, however, we cannot admit that this important element in meteorology can be determined even by the help of the most copious spring, with all the facility that has of late been supposed. A single observation at any season of the year has been represented as sufficient, not only to fix the true mean temperature, but, by a comparison with the standard temperature at the level of the sea, given by the formula stated above, to determine with precision the elevation of the place; an opinion which, besides leading to erroneous conclusions in particular cases, appears calculated to retard the general progress of meteorological science. Even the advocates for this summary method of determining mean temperatures, have produced only one instance of a spring in which there is scarcely any sensible increase or diminution of heat throughout the year, viz. the fountain of Vaucluse, whose temperature, it is said, does not vary *one tenth* of a degree, though, by some strange mistake, the variation is elsewhere stated, *on the same authority*, to be upwards of *two degrees*. This last quantity, we believe, will be found in general to be the range even of the steadiest springs, and no confidence therefore can be placed in any conclusion that may be drawn from a single observation. Before we can depend on such an observation, as determining the mean temperature, we must have previously ascertained, either that the spring does not sensibly change from one season to another, or that, at the time of observation, it was at its mean annual temperature. The remark applies still more forcibly to the measurement of altitudes. It is well known, and indeed may be inferred, from the very nature of springs, that the higher and more extensive the collecting surface of a spring, or the lower the point at which it issues, the more steady will be its temperature. In proportion, therefore, as the spring is elevated, the more liable will it be to variations, and the greater the necessity of multiplying observations to determine its mean temperature. Nor is this the only circumstance that affects the accuracy of the result thus obtained. The temperature of the atmosphere, in this climate, is found to diminish in proportion to the height above the level of the sea, at the rate of one degree of Fahrenheit for every 90 yards of ascent; so that an error of a single degree in taking the temperature of the spring, will produce a difference of 270 feet in the altitude of the place. Mr. Leslie has indeed given one instance, in which the elevation of two points on the same hill, determined in this way, agrees almost exactly with the altitude found by levelling; but it must be obvious, that a single coincidence of this kind, which might be purely accidental, is not sufficient to remove the objections now stated. The Crawley and Black springs, on the ridge of the Pentland Hills. were examined, and their temperature found to be 46°.2 and 45°. These quantities being subtracted from 48°.3, the standard temperature of the latitude at the level of the sea, according to Mr Leslie's formula, and the differences multiplied by 270, the products are 567 and 891, for the respective heights of the springs. The real heights found by levelling were 564 and 882. This coincidence is no doubt very remarkable; and there is one point in which it is perfectly satisfactory. The difference of temperature between the two springs is 1°.2, which, multiplied by 270, gives 324 feet for the elevation of the one above the other, being only 6 feet more than the real difference, as found by levelling. So far it illustrates the law by which a diminution of temperature takes place according to elevation; and had the temperature of the springs been compared with that of another equally permanent, at the level of the sea, we have no doubt that the absolute, as well as the relative altitudes, would have come out very near the truth. We have already seen, however, that the standard temperatures, as found by Mr. Leslie's formula, are far too vague and uncertain to be employed in a calculation, where a single degree above or below the truth produces an error of such magnitude in the result; and until these be verified by a more extensive induction of facts, the above coincidence must be regarded as purely accidental.

In April 1813, we instituted a series of observations on the temperature of water raised by an excellent pump, from the depth of 25 feet, and continued them till September 1816. The results of the whole show, that, even at this depth, the fluctuations of temperature are very considerable; but we shall confine ourselves to the observations of the two entire years, 1814 and 1815, that we may have an opportunity of comparing them with the means of the daily extremes in the open air. For a few months of 1814, the maximum and minimum were not observed, but the blank has been filled up from other observations, which have been found, for a series of years, to bear a certain relation to the mean of the extremes. The temperature of the water was taken three times a month, at equal intervals of 10 days; and the following table exhibits the mean of the three observations.

	Temp. of Water. 1814.	Mean of Extr. 1814	Temp. of Water. 1815.	Mean of Extr. 1815.
January,	44.3	25 1	43 4	31.9
February,	43.8	35.0	42 7	39.6
March,	42.2	37.0	42.5	40 1
April,	42.7	48.0	43 1	44 6
May,	44.1	48 0	44 5	52 4
June,	45.0	54 6	45.4	56 7
July,	45.7	61.1	46 1	58.4
August,	46 5	58 5	46.8	57.8
September,	47.2	53 7	47.4	53.4
October,	47.8	46.1	48.1	47.2
November,	47 5	39.1	48.4	36 1
December,	45.3	36.1	46.2	31 8
Mean,	45.2	45.2	45.4	45.8

It appears from the above table, that the temperature of the ground, at the depth of 25 feet, arrives at its minimum about the month of March, and at its maximum in October or November, according to circumstances afterwards to be noticed. The difference of the highest and lowest monthly average in 1814 is 5°.6, and in 1815, 5°.9; but if we compare the single observations of these months, we shall find that the range is considerably greater. In 1814 it amounted to 6°, and in 1815, to 6°.4. On the 20th of March, 1816, it stood at 40°.4, and on the 20th of August in the same year, at 48°.4, being a variation of 8°.

These facts are calculated to throw considerable light on the gradual diffusion of heat through the interior of the ground. From experiments lately made with thermometers placed at various depths, from one to eight feet, it is found that, during the summer season, a current of heat is passing regularly, but slowly from the surface downwards, as long as the mean temperature of the atmosphere is higher than that of the interior; and that in winter the current flows upwards towards the surface, to supply the deficiency produced by the external cold. In this way an equilibrium is gradually established in the temperature of the earth at moderate depths, and is found to take place twice a-year, viz. about May and October.

From all that we know of the nature and diffusion of heat, it is impossible to doubt the existence of such a current as is here stated; or its tendency in all cases to move from the warmer towards the colder region. In estimating its progress, however, a very important element seems in general to have been overlooked, we mean the influence of rain, in conveying heat or cold to the interior strata of the earth. The current alluded to might, perhaps, be thought sufficient to account for the fluctuations of temperature a few feet below the surface, but seems altogether inadequate to explain the changes which we have seen take place at the depth of 25 feet. A thermometer 8 feet deep does not arrive at its highest and lowest temperatures till two months after the extremes of the year; yet we find water at the depth of 25 feet reaching its extremes in less than three months. This fact, we think, can only be explained, by referring to the commonly received opinion respecting the origin of springs; which ascribes them to water deposited from the atmosphere on the higher grounds, and passing through the earth as a filter, till, being arrested by an impermeable stratum, it flows along the surface of that stratum, and bursts out in springs, or is intercepted by pits dug for the purpose. The rain and melted snow of winter, being cooled down on their first entering the ground far below the mean temperature of the interior of the globe, successively abstract, from the strata through which they pass, a portion of caloric; and though the quantity of water is not such as to cool the whole mass more than a few degrees below the mean temperature, yet it is obvious that the diminution must continue till the surface again approaches the temperature of the interior. This equilibrium will take place towards the middle or end of March, as the surface of the earth is then generally within a few degrees of the mean annual temperature. It is found, accordingly, that the temperature of the interior, as indicated by the pump water, is actually a minimum about the middle of March. From that period, it gradually increases, and appears to reach its mean about the middle of June. The rain and dews, however, of the succeeding months, being still at a comparatively high temperature, communicate additional heat to the strata beneath, and must continue to do so, till the surface of the ground again descend towards the temperature to which the interior has risen. This point, for the reasons already stated, will be a few degrees above the mean, and of course the equilibrium ought to take place about the beginning of October, as the temperature of the atmosphere is then generally within a few degrees of the mean annual temperature. It is obvious, however, that the ground, to the depth of several feet, may, from the accumulation of the sun's rays, be preserved at a higher temperature than the mean, even after that of the atmosphere has sunk considerably lower. This will happen to a certain extent perhaps every year; but especially in warm and dry seasons. Making an allowance, therefore, for this circumstance, the equilibrium between the surface and the interior, may be expected to take place about the end of October, which agrees exactly with observation, the pump-water being then a maximum. From this period the temperature decreases, and reaches its medium again towards the end of December.

But this view of the subject is still farther illustrated by several circumstances of a more particular nature. During the whole of the month of August, (1815.) when very little rain fell, the temperature of the water was stationary at 46°.8. In the course of September, and the first 15 days of October, when the quantity of rain considerably exceeded the evaporation, the temperature rose to 47°.8, being 1° in about fifty days; and between the 15th and 25th of October, during which time there fell upwards of two inches of rain, with little evaporation, it rose to 48°.8, being 1° in about one-fifth of the preceding interval. (See *Annals of Phil.* May, 1816.)

During the month of July 1816, though very wet, the temperature ranged only between 45° and 45°.7, the interior having then arrived at its mean annual temperature; but, in the course of 13 days in August, when a great deal of rain fell, the water rose from 46° to 48°.4. It is easy to see from these facts, that the interior of the earth may reach its extreme temperature sooner or later one year than another, according to the quantity of rain, and the periods at which it falls; and it is equally obvious, that every register of thermometers below the surface, ought be accompanied with a corresponding register of the rain gage.

But the most important fact established by the above observations, is the remarkable coincidence between the average temperature of the earth at the depth of 25 feet, and the mean of the daily extremes. Without resting on the result of 1814, when the observations of the maximum and minimum were for a time interrupted, that of 1815 is most satisfactory. Our observations on the pump water, did not extend to the conclusion of the year 1816, but taking the averages of the 12 months, from July 1815 to June 1816, during which time our register was carried on with the most scrupulous attention to accuracy, the coincidence is equally striking. The results are as follows:

Years.	Mean temp of water.	Mean temp of atmosph.	Difference.
January to December, inclusive, 1815. .	45.4	45.8	0.4 —
July 1815, to June 1816, inclusive, . . .	44.9	44.4	0.5 +

In the one case, the average of the water is four-tenths of a degree lower, and in the other it is five-tenths of a degree higher, than that of the atmosphere, which gives a mean difference of only *half a tenth* of a degree.

But it appears that the temperature of the ground at any depth, if taken regularly at equal intervals, will give a result, differing very little from the mean of the daily extremes in the open air. Since the beginning of 1818, we have observed the temperature of water issuing from a pipe, after passing through a distance of about 300 yards, at the average depth of 3 feet below the surface, and find that its mean annual temperature coincides very nearly with that of the daily maximum and minimum. The water, before being collected in the first or highest cistern, is brought in different directions, and from a considerable distance, in covered ditches, cut for the purpose of draining a large field. After issuing from the cistern, it is conveyed by an earthen pipe upwards of 200 yards before it flows from the stop cock, where the temperature is taken, and at every observation, which is made about the 5th, 15th, and 25th of each month, it is allowed to run five minutes, during which time the thermometer is found to become stationary. This mode of estimating the average heat of the interior appears to us to be more accurate, than sinking a thermometer to the same depth in any given spot, where the fluctuations of temperature must be more or less rapid and irregular, according to the nature of the soil. The following are the results of our observations.

Years.	Mean temp. of water	Mean temp. of atmosph	Difference.
January to December, inclusive, 1818, .	47.4	47.2	0.2
July 1818 to June 1819, inclusive, . . .	48.1	47.7	0.4

In both cases, the mean temperature of the water is higher than that of the open air, but the average difference is only *three-tenths* of a degree.

From these and the preceding facts, we think ourselves justified in maintaining, that the average of the daily extremes, found by a self-registering thermometer, may be more certainly depended on, as giving a near approximation to the true mean temperature, than observations made at any particular hours, and that in establishing this fact we are doing essential service to the science of meteorology. The great desideratum in thermometrical observations, is uniformity in the method of determining the mean temperature, and until such uniformity be introduced, this department of the science will still continue, what it has hitherto been, in a state of infancy. We admit, however, at the same time, that it is a very interesting inquiry, at what hour of the day the temperature approaches nearest to the true annual mean, and we shall now state the results of certain observations on this point, assuming the average of the daily extremes as the standard.

If the register kept by the Royal Society of London can be depended on, it would appear that the mean of 8 in the morning, and 2 in the afternoon, does not differ much from the mean of the maximum and minimum. Unfortunately, however, the observations are not always made at the same hours, nor has the self-registering thermometer, which was accidentally destroyed in November 1810, been since replaced. During the 16 years preceding that, viz. from 1794 to 1809 inclusive, the annual mean temperature at 8 in the morning, and 2 in the afternoon, was uniformly a little higher than the mean of the daily extremes, but the average difference for the whole period, amounted only to half a degree. Could confidence be placed in the accuracy of the observations, the result is a very important one; but strangely at variance with the opinion of a celebrated philosopher, stated in the Philosophical Transactions of Edinburgh, that the mean temperature at 8 in the morning, may be supposed to be nearly the true annual mean.

From our own observations we have found, that the average of 10 o'clock, morning and evening, coincides very nearly with that of the daily extremes. Owing to accidental circumstances, we cannot give a comparative statement of the two for the whole of every year, since the commencement of our meteorological register, but the following appear to be sufficient for establishing the fact. Taking the means as far as tenths, or one decimal place, the difference between the average of 10 morning and evening, and that of the daily maximum and minimum, is—

For 2 months of 1812, - -	0.0
11 months of 1813, - -	0.3
7 months of 1814, - -	0.7
12 months of 1815, - -	0.0
8 months of 1816, - -	0.3
12 months of 1817, - -	0.6
12 months of 1818, - -	0.3
7 months of 1819, (to this date,)	0.5
71	0.3

being little more than *three-tenths* of a degree, on an average of 71 months. In the general averages, the mean of the extremes, when there is any difference, is found to be always above the mean of 10 and 10; but it is not uniformly so, in the monthly average, excepting 1817 and 1819, when the excess was always on the same side. It might be inferred from this, that where self-registering thermometers are wanting, the mean temperature may be found with tolerable accuracy, by noting the thermometer daily at 10 morning and evening. According to the observations made at Kinfaun's Castle, the mean of the daily extremes, on an average of 6 years, is 1°.3 higher than the mean of 8 in the morning singly, and 1°.7 higher than the mean of 8 in the morning and 10 at night together.

In a paper inserted in the Transactions of the Royal Society of Edinburgh for 1800, Mr. Playfair proposed, instead of striking the average temperature once a month, as is usually done, to divide the whole year into decads, or portions of 10 days, and to find the mean of each. Twenty-one of these decads, viz. from the 20th of March to the 20th of October, he calls the vegetating season, and supposes that it is on the mean temperature of that season, that the quantity of the crop in a great measure depends. He assumes 40° as the lowest temperature at which corn will vegetate, and considers 56° as the mean temperature of a good vegetating season, so that the range between the mere germination of vegetables, and the fullest maturity to which they can attain in this climate, is 16 degrees. Mr Playfair gives the following as the result of his own observations for three years.

Years.	Mean temp. of the year.	Mean temp. of veget. seas.
1797	48.04	53.32
1798	49.28	56.17
1799	46.18	51.27

Whether the quantity of the crop, he adds, "may be expected to be proportional to the excess of the mean temperature of the vegetating season above 40, so that the crop of 1799 would be to the crop of 1798 as 2 to 3, or in a greater or less ratio. may deserve to be more accurately considered. There is reason however to think that the variations of the crop, at least corn, will be greater than in proportion to the variations of temperature; for if the mean heat of the vegetating season were to fall as much below that of 1799, as the mean of 1799 did below that of 1798, it would be reduced to 46, a temperature so low as would certainly prevent the ripening of corn altogether. By doubling the deficiency of the heat therefore, we do a great deal more than double the deficiency of the crop, so that the latter varies in a higher ratio than the former. The limit at which corn will not ripen, is probably higher than 46, and may perhaps be stated at 48."

In illustration of Mr. Playfair's theory, we shall state the mean temperatures of the seasons from 1815 to 1818. with the corresponding prices of meal, according to the fairs of the county where the observations were made. These prices cannot be supposed to be exactly in the inverse ratio of the quantities of grain, but still they will afford a general idea of the relative qualities of the crops.

Years.	Mean temp of the year.	Mean temp of veg. seas.	Excess above 40°	Price of meal per boll.		
1815	45.8	52.9	12.9	£0	14	0
1816	44.4	49.9	9.9	1	6	4
1817	46.1	50.5	10.5	1	6	0
1818	47.2	52 4	12.4	1	3	6

Many of our readers will probably recollect, that a considerable proportion of the corn crop in this country, in 1816, did not arrive at full maturity, and that its inferiority to that of the preceding year was much greater than the difference in the temperatures of the vegetating seasons. In both these respects, therefore, Mr. Playfair's conjectures are fully verified, and we have no doubt that a more extensive collection of observations on the principle which he has recommended, taking care to extend or shorten the length of the vegetating season according to the latitude, would throw much light on the interesting subject of climate; but we must leave this to be more fully discussed under the article PHYSICAL *Geography*.

As we have already found that observations of the thermometer at 10 morning and evening, give nearly the true mean temperature, there is reason to conclude that they are as likely as any other hours to give the mean height of the barometer and hygrometer, when these instruments are not constructed so as to register the extreme points to which they may rise or fall in the absence of the observer. Self-registering barometers are easily constructed, and have sometimes been used, but as from the increased friction they are not susceptible of great accuracy, we do not know that more satisfactory results are to be expected from employing them. It is difficult, indeed, to find two barometers of one kind, even by the best makers and on the most approved principles, that will exactly coincide, nor is it easy in any case, to avoid errors in adjusting the instrument for observation. From this circumstance, as well as from the irregularity formerly complained of in the times of observing, barometrical registers are perhaps still more imperfect than those of the thermometer. Before any comparison can be instituted between two such registers, it must be previously ascertained that the mercury employed in both barometers is of the same specific gravity, that the mode of adjustment, or contrivance for bringing the surface of the mercury in the basin to the commencement of the scale, is the same in each, and that the observations are made precisely at the same hours. These points being determined, it is still farther necessary to make allowance for difference of temperature and elevation, by both of which, especially the latter, the length of the mercurial column is considerably affected. Such of our readers as are conversant with the use of the barometer, must be aware of the difficulty of avoiding all these sources of fallacy, in registering the indications of that instrument. We have found from repeated experiments, which have been confirmed by those of an eminent artist. that in bringing the surface of the mercury in the basin to the point from which the scale commences, the adjustment should always be made in the same direction, and that it should not be elevated in one observation, and depressed in another. In our observations, whatever may be the state of the instrument, we uniformly bring the mercury below the true point, so that the final adjustment is always made by elevating the mercury in the cistern.

In order to exclude irregularities arising from difference of temperature, every barometrical observation might be reduced to what it would be, were the temperature of the mercurial column at 32°. This might be done very simply, and in most cases with sufficient accuracy, by allowing 3-thousandths of an inch for every degree that the temperature differs from 32°, and either subtracting that quantity from, or adding it to the observed height, according as the temperature is above or below 32°. The rule, strictly speaking, applies only when the observed height is 29.5, but in the ordinary range of the barometer, the error is not very considerable.

A similar correction might be made, and with great facility, for the difference of elevation between the positions of different barometers. It has already been remarked, that at moderate heights, the mercurial column sinks one-tenth of an inch for every 90 feet of perpendicular ascent. Every barometrical observation, therefore, may be reduced to what it would be at the level of the sea, by allowing 1-thousandth of an inch for every foot of elevation, and adding that quantity to the observed height. Like the former, this correction is only an approximation to the truth, but on a subject where there are so many other sources of fallacy, extreme accuracy in one point is, in the language of an eminent writer, an utter waste of the powers of calculation. We shall now illustrate the application of these corrections by an example.

Suppose the barometer is observed to stand at 29.565, the attached thermometer being at the same time 55°, or 23° above 32°, and the height of the place of observation 150 feet above the level of the sea, required the altitude of the mercurial column, corrected as above.

Observed height - - - - - -	29.565
Deduct for temperature, .003×23 - -	.069
Altitude if the mercury were at 32° -	29.496
Add for elevation of the place, .001×150	.150
Altitude at the level of the sea - -	29.646

Though these corrections are simple and of easy application, it is not likely that they will be generally adopted, nor, if they were, could we expect to find a very close coincidence between the results of different barometrical observations. The various degrees of delicacy in the instruments themselves, as well as of accuracy in observing them, are sufficient to prevent a constant harmony between two barometers, even when placed in the same circumstances; and we have often found that in the case of very slight fluctuations, one has been elevated, while another appeared to be depressed. At the same time, the observations that have already been made, have established some interesting facts regarding the simultaneous fluctuations in the weight of the atmosphere at different, and even very distant places.

In a paper drawn up by Professor Pictet of Geneva, and published in the second volume of Thomson's *Annals*, we have a comparative view of the state of the barometer at London, Paris, and Geneva, from 22d Sept. 1806 to 22d Sept. 1807. The elevations and depressions of the mercurial column are represented by curve lines, with the day of the month marked above or below the extreme fluctuations, so as to show at one glance both the time and the extent of these fluctuations. Were the changes in the weight of the atmosphere simultaneous and equal at the different places where the barometer was observed, and were the observations made at the same instant, and with the same degree of accuracy, it is obvious that the curve lines should be always parallel to one another. But though, in point of fact, this is found not to be the case, the deviations from parallelism are not greater than might be expected from the sources of difference and inaccuracy already noticed. The extreme elevations and depressions appear to take place generally on the same day, and nearly to the same extent; and it may be inferred, therefore, that changes in the weight of the atmosphere, at London and Geneva, are almost simultaneous. Pictet indeed has stated, that the fluctuation, when there is any difference in point of time, commonly takes place at London sooner than at Geneva; and he therefore lays it down as a general principle, that the disturbance of atmospherical equilibrium travels from the north towards the south. This principle, however, has not been verified by other and later observations. In a paper by Lord Gray, inserted in the 2d volume of the *Memoirs* of the Wernerian Society, a comparative view is given of the state of the barometer at Gordon Castle, latitude 57° 38′, Kinfauns Castle 56° 24′, Greenwich 51° 29′, and Plymouth 50° 26′ for 1814, and at the first, second, and fourth of the above places for 1815, on the same plan as that adopted by Professor Pictet. From this view, it appears that the fluctuations as before are nearly simultaneous; but when there is any difference in point of time, the change commences in the south just as frequently as in the north. We suspect, indeed, that this apparent difference is in a great measure owing to inaccuracy in observation. When the barometer continues either to rise or fall for a considerable time, its motion becomes slower as it approaches its extreme elevation or depression; so that between the evening of one day, and the morning of the next, it may have risen or fallen only a few thousandths of an inch. Unless, therefore, both observers are equally accurate, one barometer may have appeared to rise and the other to fall, and consequently the extreme elevation or depression to have taken place on different days.

The same uncertainty, arising from the same causes, attaches to many other observations that have been made, and conclusions that have been drawn, respecting the changes that take place in the pressure of the atmosphere. We allude particularly to certain periodical fluctuations, which, it is alleged, have been detected in the barometrical column, at different times of the day, and in different positions of the moon. We do not question the existence of certain causes operating on the atmosphere, and producing at regular intervals a change in its density; but we apprehend that amidst so many other disturbing causes, and where observations are so liable to error, we can know very little with certainty either of their nature or extent. Mr. Howard has stated, that on an average of ten years, he finds the barometer is depressed one-tenth of an inch, while the moon is passing from the quarters to the full and new; and elevated in the same proportion during the return to the quarter. There can be no doubt that the combined attraction of the sun and moon must operate more powerfully than that of either of them singly, in diminishing the gravity of the atmosphere; but whether the quantity of this disturbing force is such as can be estimated apart from others, is still we think very doubtful. A daily periodical fluctuation of the barometer has also been observed to take place within or near the tropics; but it does not appear to depend in any degree on the state of the moon. From a meteorological table kept at Seringapatam for 1816, and which we have now before us, we find that the barometer almost uniformly stands higher there in the forenoon than in the afternoon, at all seasons, and at every period of the moon's age. From the regularity of this change, there is no doubt that it depends on some fixed cause; but it seems very difficult to account for it, and the more so as the temperature is generally highest while the barometer is lowest. The multiplication of accurate registers in the tropical climates, where the range of the mercury does not exceed half an inch, may perhaps in time afford the means of solving this, as well as other interesting questions on the subject of atmospherical pressure.

In our climate, the fluctuations of the barometer seem to depend, in a great measure, on the direction and force of the wind. In serene and settled weather, the mercury generally stands about 30 inches at the level of the sea, and before or during storms it sinks below 29. The range is commonly stated at 3 inches, viz. from 28 to 31 inches; but it appears doubtful whether an accurate barometer on the sea shore will ever reach either of these extremes. According to the most accurate observations, the average height seems to be 29.830, and the range 2.5 inches. When the wind blows from the north-east or east, the mercury generally stands above the mean height, and below it when the wind is from the south-west. To this, however, as well as every other general maxim on the subject of the barometer, there are numerous exceptions. The greatest elevation of the mercury that we have observed during the last six years was on the 30th November, 1816, and it took place with a west wind. On the morning of that day, a barometer, 185 feet above the level of the sea, stood at 30.640, and in the evening at 30.602, corresponding respectively to 30.825, and 30.787 on the sea shore. Sudden or violent gales of wind are generally preceded or accompanied by a depression of the mercury, which continues to fall as long as the gale increases, after which it usually rises with as great rapidity as it fell. The greatest depression of the barometer that has been observed in this country for many years, took place on the 5th of March 1818, with a south-west wind. The weather, for a considerable time before, had been stormy and unsettled, with hurricanes of snow and rain from the west. On the evening of the 4th the wind shifted to the east, the barometer at the same time sinking rapidly. During the night the wind got round again to the south-west, and at eight on the morning of the 5th the barometer stood at 27.970, corresponding to 28.155 at the level of the sea. On the same night the tide rose unusually high in the river Tay, though it was only the first of the spring tides, being two days prior to the new moon; and at the time that these phenomena were observed in latitude 56° 24′, a violent hurricane was experienced at London, and various other places in the south of England. It frequently happens, indeed, that the barometer sinks during a gale of wind at a distance, while the atmosphere at the place of observation is calm and settled. We recollect having on one occasion, during close foggy weather, observed an unusual depression of the barometer, unaccompanied with wind, but afterwards found that it was contemporaneous with a violent and disastrous storm on the coast of Norway.

Many other facts might be stated, to show that the fluctuations of the barometer are almost always proportional to the strength and variableness of the wind. In the tropical climates, where the latter is gentle and steady, the range of the mercury is limited to a few tenths of an inch, but increases rapidly from the tropic towards the pole, where the winds are more violent and irregular. In like manner, the elevations and depressions of the mercury in the middle and higher latitudes, are greater and more frequent in winter than in summer. We have found, on an average of three years, that for the six months beginning with April and ending with September, the mean monthly range of the barometer, or the mean space between the highest and lowest observation during the month, is to that of the other six months in the proportion of 5 to 8. The same proportion will also be found to hold between the two seasons in the mean daily range. In our register for 1818, we noted in separate columns the differences between every two consecutive observations, which were made at ten morning and evening, and extended to a third column the sum of the two daily differences, as the range for the preceding 24 hours. The following is the result:

Mean range for 24 hours, from April to Sept. inclusive, - - - - - -	.174
Mean do. for the other six months, - -	.273

being nearly in the proportion of 5 to 8.

It appears from the reports of Captain Christian, who carried out one of Adie's sympiesometers to the East Indies in 1816; of Captain Ross and Lieutenant Robertson, who employed one on board the Isabella discovery ship; and of Mr. Stevenson, engineer to the Scots light house board, that this instrument is still more easily affected than the mercurial barometer by approaching gales of wind. From a register kept by Lord Gray of the contemporaneous indications of the sympiesometer and barometer, as well as from observations which we have had an opportunity of making with the same instrument, the former seems to be at least as delicate as the latter; but it is not quite apparent that the differences between the two instruments always indicate a greater degree of delicacy in the sympiesometer. We have now before us a register of that instrument for one month, with the corresponding indications of a very accurate barometer taken twice a-day, the range of the mercury during the period being from 29.190 to 30.380, and the temperature from 54° to 64°. Throughout the whole of these observations, the sympiesometer stood higher than the barometer, which might perhaps be accounted for from some inaccuracy in the construction of the instrument; but it is not so easy to explain the fact, that this difference has been gradually on the increase. At the commencement of our observations, it remained for some days nearly stationary at .030, but during the last eight days it has varied from .060 to .075. In the course of Lord Gray's observations a similar increase took place, which was afterwards however succeeded by a diminution. It would be premature, therefore, to decide on the merits of the instrument from such a limited number of observations, though they naturally lead to the suspicion that a certain degree of absorption has taken place between the oil and the gas. But however this may be, there can be no doubt that the sympiesometer is, on some occasions, affected by changes in the weight of the atmosphere, which are too minute to make any sensible alteration in the mercurial column, owing we conceive to the greater friction of the latter on the internal surface of the tube.

From these, and many other facts that might be produced, there can be no doubt of the relation between the fluctuations of the barometer and the state of the weather, particularly with regard to wind. It does not follow, however, that the latter can in strict propriety be assigned as the cause of the former. To say that such a relation exists, is merely the statement of two contemporaneous events, and still leaves the true cause altogether unexplained. Wind itself is the effect of some disturbance in the equilibrium of the atmosphere, by which the barometer must necessarily be affected, and it therefore remains to inquire by what means that disturbance is produced. We shall resume this subject, when we come to examine the phenomena of wind and rain; but before doing so, it will be necessary to consider the results of hygrometrical observations.

We have already had occasion to notice the imperfection of all the various hygrometers that were employed, previous to the invention of the thermoscope or differential thermometer; and we have still to lament that this delicate instrument has hitherto been so little used by meteorologists. It is also matter of regret, that in the few cases where it has been used, care has not always been taken to give either the precise time of the observation, or the corresponding temperature. The consequence is, that we know very little regarding the mean height of the instrument under any latitude, and still less of the true relative or absolute humidity of the atmosphere, even when its indications have been noted. To ascertain the true mean height, the self-registering hygrometer described above is perhaps indispensably necessary; but if the instrument in its simplest form has hitherto been so seldom employed, it is hardly to be expected that a more complex one will soon be brought into general use. In the mean time, however, there is a method by which this desideratum may, in part at least, be supplied. It has already been shewn, that the mean temperature at ten morning and evening does not differ from the mean temperature of the whole day, and since the relative humidity of the atmosphere depends not a little on temperature, it may be inferred that the mean of the hygrometer at these hours, will be an approximation to the mean of the day. It is upon this principle that we have hitherto registered the hygrometer, and we shall now state the mean height of the instrument, as well as of the thermometer, for each month of the last two years.

Months.	1817.		1818.	
	Mean of 10m. & 10 e.		Mean of 10 m. & 10 e.	
	Ther.	Hygr.	Ther.	Hygr.
January,	38.5	7.4	36 6	6 7
February,	40.1	9.7	35.1	7.0
March,	38.5	12 2	37.1	10 6
April,	44 6	21 6	40.3	16.0
May,	45.8	19.1	49.8	13 6
June,	54.4	17.3	58.5	26.5
July,	55 8	16.8	59.7	19.3
August,	54.1	14.9	56 4	21.5
September,	53.2	14.1	52 9	15.9
October,	41.4	10.5	51.4	10.0
November,	45.0	7.1	46.9	7.7
December,	34 1	5.6	38.6	6.7
Means.	45.4	13.0	46.9	13 4

From the above, and other observations made in 1814, 1815, and 1816, it appears that the mean height of Leslie's hygrometer, situated 185 feet above the level of the sea, 20 miles from the coast, and under the latitude 56° 24′, is about 13 2. This fact, however, conveys no definite idea respecting the actual humidity of the atmosphere, nor can the indications of the instrument, taken by themselves, furnish us with any correct information on this subject. It has been shewn, under the article Hygrometry, that these indications are of no use, unless the state of the thermometer at the time of observation be also known, because it is found from actual experiment, that though the absolute quantity of moisture in the atmosphere should remain unchanged, the hygrometer will rise with an increase, and fall with a diminution of temperature. When the hygrometer stands at zero, or when the wet and dry thermometers indicate the same temperature, it may be inferred, whatever the temperature be, that the atmosphere is completely saturated with moisture; but should the temperature increase, the hygrometer will also rise, and continue to do so indefinitely, with every new accession of heat, though the actual quantity of moisture remains undiminished. In the article referred to, a formula is given, by which the indications of the hygrometer, which are of themselves vague and without any distinct meaning, may be converted into precise and definite expressions. The most important facts which may be deduced from that formula, are the three following.

1*st*, The point of deposition. It is known from the law which regulates the solution of water in the atmosphere, that a portion of air holding any given quantity of moisture in a state of vapour, will, if cooled down, arrive at a temperature where it will become saturated, or incapable of dissolving more moisture than it formerly contained, and consequently, if its temperature be farther diminished, it will begin to deposit a portion of that moisture in the form of dew or rain. The temperature at which it begins to do so is called the Point of Deposition.

2*d*, The actual quantity of moisture in a given portion of the atmosphere. This quantity is expressed by the formula in decimals of a grain in one cubic inch; but as the fraction is small, we have expressed it in our register, by decimals of a grain in 100 cubic inches.

3*d*, The relative humidity of the atmosphere. It was observed above, that in the hygrometer, zero is a fixed point denoting complete saturation, but that the scale extends upwards indefinitely, or in other words, there is no point in the scale which at all temperatures denotes absolute dryness. By the formula alluded to, this defect is completely remedied. Absolute moisture being denoted by 100, and absolute dryness by 0, it may be determined what intermediate degree of moisture is indicated by any given state of the hygrometer. This is in fact converting an indefinite into a definite scale, and by employing 100 to denote extreme moisture, all other quantities are expressed in hundredths of what would produce complete saturation. These three particulars may be illustrated by the following example.

Suppose that, at any given hour the hygrometer indicates 20, according to the millesimal scale, and the thermometer in the same circumstances 50; required the point of deposition, the actual quantity of moisture in 100 cubic inches of air, and the relative humidity.

By applying the formula, it will be found that the point of deposition is 40°.3 Fahrenheit, the actual quantity of moisture in 100 cubic inches of air 0.178 of a grain, and the relative humidity 73; that is, the atmosphere, in these circumstances, contains 73 hundredths of the whole moisture which it is capable of holding in solution at the temperature of 50, and which amounts to .178 of a grain in 100 cubic inches; and if the temperature were reduced to 40°.3, the hygrometer would sink at the same time to 0°, after which the moisture would begin to be deposited.

Let us suppose, now, that the hygrometer, as before, indicates 20, but that the temperature is 60. In this case the point of deposition will be found to be 53°.1, the actual quantity of moisture in 100 cubic inches 0 269, and the relative humidity 80. Such are the different degrees of moisture which may actually exist in the atmosphere, while the hygrometer stands at the same point.

We are aware that the labour and difficulty of calculating the result of each single observation may be urged, and indeed will probably operate, against the general use of the formula. This objection, however, it is to be hoped, will soon be in a great measure removed, by the labours of the same individual to whom the scientific world is indebted for the original and profound speculations of the article alluded to. Mr. Anderson proposes to construct a table, in which, from the indications of the hygrometer, in any given state of the thermometer and barometer, the three facts stated above may be found by inspection. In this table, we believe, the indications of the hygrometer are to be expressed in degrees of Fahrenheit instead of the millesimal scale, and the calculations are to be adapted to different heights of the barometer. In a table which we have constructed from the same formula, we have retained the millesimal division of the hygrometer, and adapted the whole calculation to one state of the barometer, viz. 29.640, which we found to be the mean height at the place of observation. The results are perhaps as near the truth as the nature of the subject requires; and at all events the errors arising from the fluctuations of the barometer cannot materially affect the annual mean. They are so inconsiderable, indeed, as scarcely to affect the accuracy even of a single observation, as is evident from the following example.

Suppose that on two different occasions the hygrometer indicated 30° and the thermometer 50°, but that the barometer in the one case stood at 30 inches, and in the other at 29. By the formula, the quantity of moisture in 100 cubic inches of the atmosphere expressed in decimals of a grain, is 146, when the barometer is at 30, and .144 when it is at 29, being a difference of only 002, corresponding to a fluctuation of one inch. A table, therefore, calculated for the mean height of the barometer, will be sufficiently accurate for all meteorological purposes.

It was inferred, from the principles investigated in the article HYGROMETRY, that the mean quantity of moisture in the atmosphere on any given day, will correspond nearly with what would produce complete saturation at the minimum temperature of that day; and this conclusion was verified by a reference to meteorological observations for 1815. From accidental circumstances, it cannot be expected that this coincidence should take place every day, but it was found to hold very nearly in the means of the whole year, and is farther confirmed by the following observations for 1818. The last three columns contain the mean results of 10 morning and evening.

Months.	Mean Minimum Temperature.	Mean Point of Deposition.	Grs. of Moist in 100 cub. inches.	Relative Humidity.
January,	32.1	32.0	.135	86.0
February,	30.8	29.9	.125	84.0
March,	31.8	29 5	.124	77.5
April,	34 0	28.9	.121	68 4
May,	43.9	43 9	.200	82.6
June,	50.2	48.9	.235	73 7
July,	52.1	53.0	268	81 0
August,	49.1	48.0	.228	76 2
September,	46.5	45.9	.213	80.0
October,	46 9	47.1	.222	87.1
November,	42.9	43.0	.194	88.2
December,	33.8	34 3	.145	86 3
Means,	41.2	40.4	.184	80.9

The difference between the point of deposition and the minimum temperature, in the above table, scarcely ever amounts to a degree, except in the months of March and April. In the latter it amounts to 5°; but this exception from the general rule may be easily accounted for, from particular circumstances. During that month the wind blew almost constantly from the north-east, so that a continual influx took place of dry cold air from the northern regions. This air, having its temperature increased by approaching a warmer climate, acquired also a greater capacity for dissolving moisture, and thus augmented the dryness of the atmosphere beyond what is natural to this climate; while, by the continuance of the wind from the same quarter, a new wave, as it were, flowed in before the preceding one could receive any sensible augmentation of humidity. A similar depression of the point of deposition below the minimum temperature, and arising from the same cause, took place in April 1817. During the present year (1819) the greatest depression, amounting to 3°.3, happened in the month of May, chiefly with east winds. In general the difference does not amount to a degree.

We have not thought it necessary to detail at length our observations with the hygrometer for the four years preceding 1818. In general the application of Mr. Anderson's formula to these observations, gives results corresponding nearly with those stated in the above table. It would appear, therefore, that at the place where the above experiments were made, the atmosphere, in its mean state, at 10 morning and evening, contains about 18 grains Troy in ten thousand cubic inches, being eighty hundredths, or four-fifths of what would produce complete saturation. A series of similar observations under other latitudes, and at different elevations, is still, however, a desideratum in meteorology; and till this be supplied, it would be premature to pronounce with confidence on any thing that has yet been advanced, respecting the law of aqueous solution in the atmosphere. At the same time, it is not too much, we think, to hope that Mr. Anderson's researches on this interesting branch of science will, when better known, lead to the discovery of some important facts on the formation of clouds, the production of rain, and other atmospherical phenomena.

The most satisfactory, and, at present, generally received theory, on the last mentioned subjects, (the formation of clouds and the production of rain) is that proposed by Dr. James Hutton, and first published in the *Philosophical Transactions of Edinburgh* in 1784. In this theory the author supposes, what has since been satisfactorily proved, that the dissolving power of air, or its capacity for holding water in a state of vapour, increases in a greater ratio than its temperature. From the experiments of Saussure, and others who have succeeded him in hygrometrical researches, it appears that while the temperature rises in arithmetical progression, the dissolving power of the air increases nearly in geometrical progression. This particular relation, however, is not necessary to the truth of the theory in question, which requires only that the humidity which the air is able to contain increase in a greater ratio than the temperature. This being admitted, it follows, that when two portions of air, of different temperatures, and both containing as much humidity as they are capable of dissolving at these temperatures, are mixed together, the joint quantities of moisture in the two portions will be greater than the air, after intermixture, is able to dissolve; and consequently a portion of the humidity must be condensed or precipitated. This will appear evident from the following geometrical representation.

Let the points A, B, C, D, (Plate CCCLXXIV. Fig. 9.) in the line AD, present different temperatures, and the perpendiculars Aa, Bb, Cc, Dd, the quantities of humidity which the air at these temperatures can hold in solution. From b and c draw the lines bef and cg parallel to AD, then Ce and Df will be each equal to Bb, and fg to ec; also ec and gd will represent the increased dissolving power of the air corresponding to the increased temperatures BC and CD But according to the theory, the former increases in a greater ratio than the latter; and consequently, if CD be equal to BC, gd will be greater than ec. Suppose, now, that equal portions of air, at the temperatures B and D, and both saturated with moisture, are mixed together; then the temperature of the mixture will be the mean between B and D, in this case C, and the portion at B, by having its temperature raised to C, will be able to dissolve ec more moisture than it did before, while the portion at D, by having its temperature reduced to C, will dissolve gd less than it did at its original temperature. But it was shewn that gd is greater than ec; therefore the quantity of moisture which the two portions of air held in solution in a separate state, is greater than what they are capable of dissolving after they are mixed, and consequently a portion of their humidity must be deposited by the mixture. This portion is obviously equal to the difference between ec and gd, or $=gd-ec$.

From the relation which the perpendiculars bear to one another, it is evident that the line passing through their extremities must be a curve, convex towards AD, and assuming what, from experiment, seems to be nearly the fact, that the dissolving power increases in a geometrical, while the temperature increases in an arithmetical progression, it will be a logarithmic curve. The knowledge of this fact enables us to assign, in certain cases, a precise value to the quantity deposited, or $gd-ec$. For, from the nature of the figure, we have

$$gd = \mathrm{D}d - \mathrm{C}c$$
$$ec = \mathrm{C}c - \mathrm{B}b$$

and subtracting these equations, $gd - ec = \mathrm{D}d - 2\,\mathrm{C}c + \mathrm{B}b = \mathrm{D}d + \mathrm{B}b - 2\,\mathrm{C}c$. But C$c$ being a mean proportional between Bb and Dd, $\mathrm{C}c = \sqrt{\mathrm{B}b \times \mathrm{D}d}$; therefore $gd - ec = \mathrm{D}d + \mathrm{B}b - 2\sqrt{\mathrm{B}b \times \mathrm{D}d}$. In general, let M, m, represent the quantities of moisture which two portions of air, at different temperatures, can hold in solution, when completely saturated, and let these portions be mixed together in equal quantities, so that the temperature of the mixture may be the mean of the two temperatures, then the quantity deposited will be equal to

$$\mathrm{M} + m - 2\sqrt{\mathrm{M}m}.$$

This quantity, or $gd-ec$, may also be represented geometrically. Thus, join bd, produce Cc till it meet bd in h, and draw hi parallel to cg or AD. Then the triangles beh, hid, are obviously similar and equal, and $eh=id$. Also $gi=ch$, and consequently $gd=eh+hc=ec+2ch$. Therefore the quantity deposited, or $gd-ec=2ch$.

But a deposition of moisture may take place, even though the portions of air are not both saturated before intermixture. The quantity deposited will be less indeed in proportion to the distance of the air from the point of saturation; but still a deposition will take place so long as the moisture contained in both portions at the temperatures B and D, is greater than 2 Cc. This conclusion may also be deduced from the table in the article HYGROMETRY, § 39 Thus let 30° and 50° be the temperatures of the two portions, and let each be 1° from the point of saturation; then the actual quantities of moisture contained in both will be ·002389+·001235=·003624 grs. or ·001912 grs. in one cubic inch. But a cubic inch at 40° (the mean temperature of the mixture,) can dissolve only ·001782 grs.; and consequently ·0003 grs. will be deposited by each cubic inch. See § 93 of the same article.

It appears, from the table now referred to, that when the temperature increases in arithmetical progression, the dissolving power increases somewhat faster than in a geometrical progression. Thus a cubic inch of air at 30°, when saturated, holds in solution ·00127758 gr. and at 50°, ·00246714 gr. If the solving power, therefore, increased in geometrical progression, a cubic inch at 40°, when saturated, ought to dissolve only ·001775 gr.; but, by the table, it is found to dissolve ·001782 gr. being ·000007 gr. greater. This small difference, however, does not at all affect the illustration of the general principle given above.

When different portions of the atmosphere are intermixed, so as to produce a deposition of moisture, the consequence will be, the formation of a cloud. This cloud, from its increased specific gravity, will have a tendency to sink downwards; and, were the lower strata of the atmosphere of the same temperature with the cloud, and saturated with moisture, it would continue to descend till it reached the surface of the earth in the form of rain, or what is commonly called mist. In general, however, the cloud in its descent passes through a warmer region, where the condensed moisture again passes into vapour, and consequently ascends till it reach a temperature sufficiently low to recondense it, when it will begin again to sink. This oscillation will continue till the cloud settles at the point where the temperature and humidity are such, as that the condensed moisture begins to be dissipated, and which is found, on an average, to be between two and three miles above the surface of the earth.

When the condensation of moisture is rapid and copious, there appears to be no reason to doubt, that rain will be immediately produced. Some philosophers, indeed, have maintained that such a condensation, however rapid, never can produce any thing but a cloud, and that the production of rain is the consequence of certain electrical processes that afterwards take place among the minute particles of which the cloud is composed. That electricity is a frequent and a powerful agent in the formation of rain, is extremely probable, but that it is in all cases essential to that phenomenon, appears to us to be a gratuitous assumption, which, however ingeniously supported, is still destitute of satisfactory proof. The well known fact, that the rain which accompanies a thunder storm, is more copious than in any other circumstances, is evidence sufficient that it is frequently modified or increased by the influence of electricity; but this is all that is certainly known upon the subject, and we deem it unnecessary, therefore, to enter on any particular examination of the hypothesis, that the particles of moisture in a cloud are held at a distance from each other by certain electrical atmospheres; and that it is only by the removal of these that the particles unite, and form drops of rain.

It is evident that the mixture of different portions of the atmosphere, to which, in the preceding remarks, we have ascribed the production of rain, must be greatly promoted by opposite currents of wind. These currents are themselves produced, chiefly by the unequal distribution of heat, which disturbs the equilibrium of the atmosphere. When a column of air is heated above the temperature of an adjacent column, it has a tendency to rise, in consequence of its diminished specific gravity, while the colder air flows in to supply its place. Upon this principle, it might be expected, what is found actually to take place, that the colder air, from the poles, is continually displacing the warmer and lighter air of the equatorial regions, thus producing a constant current near the surface of the earth from the pole towards the equator. To supply the place of the air thus carried away from the poles, an opposite current must flow in the higher regions of the atmosphere, from the equator towards the pole, where the air has its temperature reduced, at the same time that the air, by which it was displaced, has its temperature elevated, so that the circulation is constantly kept up. This tendency to an interchange of air between the warmer and colder regions of the globe, combined with the diurnal revolution of the earth, produces that constant current in the neighbourhood of the equator, which is called the trade wind, and which will be considered at greater length under the article Physical Geography.

The wisdom and beneficence which this constitution of things displays, appear in the provision which is hereby made for moderating the extremes of heat and cold in different climates, as well as producing the rain that is necessary for the purposes of vegetation. Were the surface of the globe uniformly smooth, and every where equally susceptible of the impressions of heat and cold, the circulation in the atmosphere would probably suffer no interruption, nor be liable to any irregularities. The variations of the barometer would, in that case, be very small, as they are found to be in the equatorial regions, where the circulation of the atmospherical currents is most steady; and rain would, in all probability, fall only at certain periods, and after long intervals. As the globe, however, is actually constituted, the inequalities of its surface, the different capacities which different parts of that surface have for absorbing or communicating heat, and other disturbing causes, produce frequent and considerable irregularities in the direction and force of the great atmospherical current, and thus give rise to the variety of winds which is found to take place above the 30° parallel of latitude. As the upper current, or that which flows from the equator, is all directed nearly to one point, viz. the pole, its velocity must be increased as it approaches that point, and consequently the effects of the disturbing causes must be greater in the higher latitudes than nearer the equator; an inference which is fully confirmed by observation. The range of the barometer, which may be considered as expressing the amount of the disturbing force, is found to increase with the distance from the equator; but that the quantities of air transported by the two currents are, upon the whole, equal, is obvious from the remarkable fact, that the mean height of the barometrical column, making allowance for difference of temperature and elevation, is nearly the same in all latitudes, where it has yet been observed. It may be supposed, therefore, that the plane which separates the two currents will be nearly at that elevation above the level of the sea, where the barometer would stand at half its mean height, and that here clouds are most likely to be formed, from the contact of two portions of air of different temperatures. This also is confirmed by observation; the height at which the barometer would stand at 15 inches being about 3.4 miles, or nearly the average height of the clouds.

The influence of different currents of air in producing rain, is demonstrated by a great variety of phenomena. In this climate, dry weather generally prevails, either when the atmosphere is in a settled state, or when the wind blows steadily from the same point.

On the other hand, a change of wind is almost always accompanied with rain; and if these changes be frequent and rapid, heavy showers are the consequence. In the tropical climates, the rainy seasons may generally be predicted with the greatest precision, as they are found uniformly to set in with the sun's approach to the zenith, when the winds become variable, or with the change of the monsoon, at which time the heaviest rains fall. In extensive inland plains, where there is nothing to promote the mixture of different currents of air, and where evaporation does not furnish moisture enough to bring the atmosphere to the point of saturation, it seldom rains; while in mountainous countries, especially in the neighbourhood of the sea, it rains frequently.

Where there are so many irregularities to be taken into the account, it seems impossible to calculate with any thing like precision, the quantity of rain that may be expected to fall at any given place in the course of a year. That quantity, indeed, must obviously bear some relation to the moisture which, at the average temperature of the year, can be held in solution in the atmosphere, compared with the yearly evaporation; and, upon this principle, an approximation to the depth of rain for every fifth parallel of latitude, has been given under the article Hygrometry. The results in that table, however, must be considered as excluding the irregularities arising from local circumstances, and cannot, therefore, be expected to give a very near approximation for particular places; but it may be interesting to inquire, how far it coincides with actual observation in our own climate.

From a very extensive collection of facts, Mr. Dalton found that the average annual quantity of rain, for 30 places in England and Wales, amounts to 35.2 inches, the greatest being 67.5 inches, at Keswick in Cumberland; and the least 19.5 at Upminster in Essex. This average, however, is, on various accounts, greatly above the truth. Of the 30 places where the observations were made, 2 are in Cumberland, 3 in Westmoreland, and 5 in Lancashire; the counties where, of all others, the quantity of rain might be expected, and is actually found to be the greatest. Mr. Dalton indeed has made an allowance for the excess arising from this circumstance, by taking a mean of the different places in the same county, and then an average for all the counties, which reduces the general mean from 35.2 to 31.3 inches; but we are inclined to think that even this is too high an average for the whole of England and Wales. Of the 20 counties where the places referred to by Mr. Dalton are situated, 13 are maritime; yet notwithstanding this great proportion of counties where the atmosphere is most likely to be humid, there are 16 of the whole 30 places, where the quantity of rain is below 30 inches. Had the observations been made at equal distances over the whole country, it is probable that the general mean would be considerably below this last quantity. Taking the mean latitude of England and Wales at 52½°, the average yearly rain by the table alluded to above, should be 23.5 inches.

We have found from our own observations, that the annual quantity of rain, in latitude 56½°, and in a situation not likely to be much affected by local circumstances, is, on an average of 6 years, commencing with 1813, 23.7 inches; and leaving out the years 1817 and 1818, when the quantity of rain was unusually great, the average is 21.5. By the table it should be 21. At another place, under the same latitude, but in the immediate vicinity of a hill 6 or 7 hundred feet in height, the average depth of rain for the same six years, is about 25.5 inches.

A question has sometimes been agitated respecting the comparative quantities of rain, that fall at the summit and base of a hill. It appears from experiment, that a rain gage, placed near the surface of the earth, collects a greater quantity of rain than one elevated above it, and the difference has been generally ascribed to the influence of the wind. It has also been supposed, that independent of this cause, the quantity must be greater below than above, owing to the gradual accumulation, and consequent enlargement of the drops in their descent through the atmosphere. Now there are only two cases in which it appears that this can take place; either when the atmosphere throughout is saturated with moisture, or when the temperature of the rain is so low, as to reduce the air with which it comes in contact in its descent, to the point of deposition. There is reason to doubt, however, whether these cases occur generally or even frequently. We have often observed the hygrometer during a heavy and even long continued rain, indicate from 5 to 10 degrees of dryness, so that instead of increasing, there is reason to believe that the drops sometimes diminish on their approach to the earth. But whatever may be the cause of the difference between the indications of two rain gages placed at different altitudes above the same plane, there can be little doubt, that the quantity of rain which falls on the summit of a hill, is greater than what falls at the base, and that the difference is easily accounted for from the well-known fact, that the nimbus or rain-cloud, as well as fogs and mists, is often attracted by mountains, and is seen to rest upon them, while there is little or no rain below. This, of course, supposes, that the hill is of considerable height and magnitude, and that the observation in this case holds true is fully established by the following facts.

In the neighbourhood of Kinfaun's Castle, a rain-gage is placed on the summit of a hill, 600 feet above the level of the sea, and another in the garden at the base of the hill, about 20 feet above the sea. The following are the annual results of the two for five years:

Years.	Hill Gage.		Garden Gage.	
	In.	Dec.	In.	Dec.
1814	33	.84	20	.05
1815	45	.70	24	.20
1816	52	.43	24	.95
1817	44	.40	31	.01
1818	31	.10	28	.07
Means.	41	.49	25	.66

No part of the above difference can be ascribed to any thing in the situation of the garden gage but its being lower down. It is fully exposed to the rain; and, as the best proof of this, it is only necessary to remark, that its average amount for six years is about two inches greater than that of another, situated in an open country, at the distance of about a mile.

When clouds are formed at an elevation, where the temperature is below 32°, the particles of moisture become congealed, and fall down in the form of snow or hail. If the temperature of the lower regions of the atmosphere be much above 32°, it will sometimes happen that the snow is again dissolved before it reaches the earth; but hail, from its greater solidity, as well as more rapid descent, frequently arrives at the ground in its congealed state even during the summer months. There can be no doubt that the moisture, of which hail consists, had been collected into large drops of rain previous to its being congealed; and Mr. Leslie has proposed an explanation of the manner in which the congelation takes place. "If we examine," says he, "the structure of a hail-stone, we shall perceive a snowy kernel incased by a harder crust. It has very nearly the appearance of a drop of water suddenly frozen, the particles of air being driven from the surface towards the centre, where they form a spongy texture. This circumstance suggests the probable origin of hail, which is perhaps occasioned by rain falling through a dry and very cold stratum of air." He then proceeds to point out a method of putting this theory to the test of experiment; but, in fact, it has been already confirmed, by the process of freezing water under the receiver of an air-pump.

From all that has been stated on the formation of clouds, and the production of rain, we are naturally led to remark, that however important may be the facts which meteorological researches are in time likely to disclose, there is but little probability of our ever being able to predict, with any thing like certainty in every case, the approach of the most common and familiar of all atmospherical phenomena. By the extended use of the hygrometer, we may discover a great deal more than we yet know of the state of the atmosphere near the surface of the earth; but we cannot from this infer any thing with certainty regarding the processes that are going on in the region of the clouds, or anticipate the nature and extent of future changes in the weather. We have repeatedly remarked, in the course of our observations, a heavy and long continued fall of rain, commencing a few hours after the hygrometer had indicated an unusual degree of dryness in the lower atmosphere; and, on the contrary, the air passing from a state of almost complete saturation to great dryness without any rain at all. The barometer is the only instrument by which distant changes in the atmosphere can be detected; but as its fluctuations merely give us notice of variations in the weight of that fluid, they do not necessarily indicate the approach of rain. In fact, the only information that this instrument gives us, is the amount of the disturbance that has taken place in the equilibrium of the atmosphere. When the mercurial column, therefore, sinks below its mean height, all that we can directly infer is, that some change has happened, or will soon happen, in the force or direction of the wind; but as this is likely to bring different or opposite currents into contact, it may naturally be expected that rain will be the consequence. It is in this way only that the fall of the barometer is an indication of rain. It may be observed, too, that the intermixture of different portions of the atmosphere, in such circumstances as to produce rain, sometimes takes place, not at the first disturbance, but at the subsequent restoration of the equilibrium; and we find accordingly, that, on some occasions, the barometer, after being depressed below its mean height, has begun again to rise before the rain commences. To illustrate these remarks, we shall extract from our register the greatest falls of rain that have taken place since 1815, with the corresponding state of the barometer, and the relative humidity of the atmosphere, at 10 morning and evening, confining ourselves to those cases in which the quantity of rain amounted to an inch in 48 hours.

Year.	Date.		Rain.	Barometer.		Relative Humid.		Wind.
				10 *m.*	10 *e.*	10 *m.*	10 *e.*	
1815,	Oct.	19,	—	29.220	29.025	86	100	W. & S.
		20,	1.338	28.825	29.030	100	97	E. var.
1816,	July	7,	1.030	29.670	29.660	93	97	E.
	Aug.	14.	—	29 690	29.500	88	1 0	E.
		15,	1.893	29.470	29.525	100	97	E.
1817,	May	26.	—	29.380	29.465	61	92	E.
		27.	1.361	29.520	29.670	88	89	N. E.
	June	9,	—	29.580	29.560	67	92	S. W.
		10,	1.119	29.640	29.820	71	92	W.
		13,	1.340	29.380	29.200	68	96	S. and E.
	Aug.	25,	1.120	29.350	28.980	92	100	E.
1818,	April	26,	—	29 510	29.555	65	81	N. E.
		27,	1.070	29.380	29.432	98	98	E.
	May	6,	—	29.310	29.290	98	97	N. E.
		7,	1.169	29.282	29.372	93	95	N. E.
	July	26,	—	29.678	29.715	82	96	W.
		27,	1.082	29.820	29.985	90	93	W.
1819,	April	13,	—	29.340	29.250	80	88	E.
		14,	1.070	29.240	29.265	92	86	W.
		15,	—	29.245	29.240	94	97	E.
		16,	1.075	29.222	28.935	97	100	E.
		20,	1.062	29.550	29.525	81	97	E.
	June	20,	—	30.105	29.970	42	83	W.
		21,	—	29.792	29.840	75	82	E.
		22,	1.120	29.850	29.895	91	84	E.

The mean height of the barometer, from the beginning of 1815 to the middle of 1819, was 29.650, and the mean relative humidity, at 10 morning and evening, about 80. The average of the barometer in the above table is 29.475, and the relative humidity 88.5. The table, however, presents many anomalies from any general inference that might be drawn from these facts. Thus, on the 7th of July, 1816, the barometer was almost stationary at a point rather above than below the mean height, not only on that but also on the preceding day, though the quantity of rain amounted to an inch in 24 hours. It may be alleged, indeed, that the wind on that occasion blew from the east; and as an east wind, in this country, generally raises the barometer two or three tenths above its mean height, the altitude of the mercury on that day was as far below what it ought to have been, as the average of the preceding table is below the average of the whole period. There are cases, however, where this explanation does not apply. On the 9th and 10th of June, 1817, and the 26th and 27th of July, 1818, upwards of an inch of rain fell; while the barometer, with a west wind, stood in the one case very little below, and in the other considerably above, the mean height. It the former case, indeed, the mercury had sunk on the 8th to 29.4, but in the latter it was almost stationary for several days.

But the most remarkable fact in the above table is, the unusual degree of dryness that sometimes existed in the lower atmosphere immediately before a considerable fall of rain. Thus, on the 26th of May, 1817, the relative humidity was 19, and, on the 20th of June, 1819, it was 38 degrees below the ordinary annual mean, though a few hours afterwards rain commenced, and in both cases exceeded an inch. It would thus appear, that the formation of rain sometimes takes place at a great height above the surface of the earth, and is altogether independent of the quantity of moisture that exists in the lower strata of the atmosphere.

But though it may be difficult to assign any satisfactory reason for the particular facts now stated, it seems to be sufficiently clear, that in general the quantity of rain that falls at any given place in the course of a year bears a certain relation to the moisture which can be held in solution by the atmosphere, at the average temperature of that place; and that the depth of rain, therefore, must depend in some degree on the quantity of evaporation. The relation between these quantities, as deduced from the law of aqueous solution in the atmosphere, may be seen from the table formerly alluded to in section 99 of the article Hygrometry, containing the quantity of rain for every 5° parallel of latitude, compared with another table in section 51 of the same article, shewing the daily and yearly evaporation for the same parallels. We have already seen that the former of these tables gives an approximation to the depth of rain as found by actual observation; and though it is difficult, perhaps impossible, to measure with accuracy the quantity of evaporation from the surface of the ground, the most satisfactory experiments on the subject give results coinciding very nearly with the quantities given in the table of evaporation.

From observations made by Dr. Dobson at Liverpool, for four years, commencing with 1772, it would appear that the annual evaporation from the surface of the water in that latitude, amounts to 36.78 inches. There can be little doubt, that where the water in the evaporating basin is freely exposed to the influence of the sun and wind, or even of the latter alone, the quantity evaporated in the course of a year may amount to 36 or 37 inches. This, however, is obviously a much greater quantity than could be dissolved by a column of the atmosphere, whose base is equal to the exposed surface, because in the case of even a moderate wind, the original rate of evaporation is kept up by a constant succession of new columns, whose bases are every instant coming in contact with the surface of the water. It must be greater also than what is actually evaporated from the earth; for though the latter is exposed to the influence of both the sun and wind, the surface in a short time becomes dry, and the moisture is not drawn up from below so quickly as to yield a supply equal to that afforded from the surface of water. There is reason, however, to believe, that the actual evaporation from the ground, in ordinary cases, approaches nearer, than that from an exposed evaporating vessel, to the true quantity of evaporation at any given place; meaning by this, the quantity which the atmosphere at that place would dissolve, were the whole surface of the globe covered with water. The ground indeed after a time ceases to supply moisture as quickly as the air is capable of dissolving it; but were the surface continually wet, the dissolving power of the air, and consequently the rate of evaporation, would diminish, and perhaps as rapidly as the supply of moisture from the earth is found to do in the present state of things. But the readiest, and perhaps, after all, the most accurate estimate of evaporation, is found by placing the common evaporating basin, or atmometer, in a situation out of the reach of the sun's direct influence, and sheltered as much as possible from the wind. The results obtained in this way, appear from the following facts to coincide nearly with those of experiments made to ascertain the actual evaporation from the earth.

By a vessel situated as above described, we found the annual evaporation in latitude $56\frac{1}{4}$°, for the last two years, to be as follows:

1817 . . . . 20.991 inches
1818 . . . . 20.056

being a mean of 20.523. The amount from September 1818 to August 1819 inclusive, is 20.765. The annual evaporation, therefore, may be stated at 20.6 inches.

From the experiments instituted by Mr. Dalton in 1796, and which have been detailed under the article Evaporation, it was found that the quantity evaporated from the ground, on an average of three years, amounts to 25.158 inches. There is reason to believe, however, from certain circumstances in the mode of conducting the experiments, that this quantity is rather above than below the truth; but even admitting that there was no source of fallacy in the observations, the result, making allowance for difference of latitude, which may be about 3°, coincides very nearly with those given above. Both results approximate to the quantities deduced by Mr. Anderson from the law of aqueous solution. By the table of evaporation formerly alluded to, the quantity corresponding to latitude $56\frac{1}{4}$° is 22.35, and for latitude 53° 24.54, being 1.75 greater in the one case, and .62 less in the other than what is found by actual observation.

It may perhaps appear at first sight, that the near approximation to equality between the quantity of rain and that of evaporation, which some of the preceding remarks seem to imply, is inconsistent with the universally received opinion respecting the origin of springs. If the evaporation be as great, or the depth of rain as small as has been stated, it may be alleged that there is not a sufficient supply of water to keep permanent springs and rivers continually flowing. It is to be remembered, however, that the quantity of rain that falls on mountains, and elevated tracts of country, greatly exceeds what is deposited in plains, or what would fall if there were no mountains; and that it is chiefly from the latter that springs and rivers derive their supply. Mr. Dalton has calculated, that the quantity of water annually discharged into the sea by all the rivers in England and Wales, amounts only to about thirteen inches of rain over the whole surface; and when it is considered that the water deposited on mountains very quickly arrives at rocks, which, from their stratified position, convey it with little waste to the point where it is to issue in a spring, there seems to be little difficulty in conceiving, that the superabundant moisture which falls there is fully adequate to the supply. There is, no doubt, in all such calculations as those of Mr. Dalton, a vagueness and want of precision; but his estimate of the quantity of water annually discharged by all the rivers in England, is just as likely to be above as below the truth.

Another phenomenon, intimately connected with the subject now under consideration, and which has of late occupied no small share of the attention of philosophers, is the formation of *dew*. From a very early period, it has been observed that dew is always most copious during clear and calm nights; and an idea seems also to have long prevailed, that it is accompanied with a reduction of temperature. The late Dr. Wells, however, was unquestionably the first person who proposed a distinct and satisfactory theory upon the subject. That gentleman has shown, by a great variety of well-conducted and accurate experiments, that dew is never formed upon any substance till the temperature of that substance has been reduced below the temperature of the surrounding atmosphere; and has consequently proved, that the cold which accompanies dew, precedes instead of following the production of that fluid. This indeed might have been inferred from the well-known fact, that vapour, in passing from the aeriform to the fluid state, gives out instead of absorbing caloric; and the formation of dew, therefore, so far from increasing, must diminish the cold of contiguous bodies. But Dr. Wells has also proved, in a manner equally satisfactory, that the surface of the ground, as well as other bodies, has its temperature reduced below that of the atmosphere, by being freely exposed to the clear sky, and that whatever screens it from this exposure, prevents the reduction of temperature. Thus he found, that on clear and calm nights, a thermometer, in contact with the grass, frequently stood from 7° to 12°, and on one occasion 15° lower than another situated four feet above the surface; and of two thermometers which were both in contact with the grass, one being freely exposed, and the other sheltered by a screen of pasteboard, the former sometimes indicated a temperature 10° below the latter. In cloudy weather, and particularly when there was wind, he seldom observed much difference between the temperature of the grass and that of the air; but, in such weather, a clear interval seldom failed to produce a great reduction of temperature on the surface of the ground, while a passing cloud over a clear sky generally raised the thermometer on the grass several degrees. Dr. Wells observed farther, that when bodies, which had been equally exposed to the air, were examined at the same time, those which had suffered the greatest reduction of temperature had also collected the greatest quantity of dew; and that substances which had been exposed to the sky were uniformly more dewed than those which had been screened. In proof of this, we shall give the result of one experiment, among many that might be produced, and which appears to be perfectly satisfactory.

"I bent a sheet of pasteboard," says Dr. Wells, *Essay on Dew*, p. 15, 1st edition, "into the shape of a house roof, making the angle of flexure 90 degrees, and leaving both ends open. This was placed one evening with its ridge uppermost upon the same grass plat, in the direction of the wind, as well as this could be ascertained. I then laid ten grains of wool on the middle of that part of the grass which was sheltered by the roof, and the same quantity on another part of the grass plat fully exposed to the sky. In the morning, the sheltered wool was found to have increased in weight only two grains, but that which had been exposed to the sky sixteen grains.

From these experiments, repeated in a great variety of ways, Dr. Wells deduced the following theory of the production of dew. On the commonly received and well-established fact, that bodies have a tendency to throw off caloric by radiation to other bodies, whose temperature is lower, he supposes that the earth is continually radiating its heat to the high and colder regions of the atmosphere; that, in the day time, the effects of this radiation are not sensible, being more than counterbalanced by the greater influx of heat from the direct influence of the sun; but that during the night, when the counteracting cause is removed, these effects become sensible, and produce the reduction of temperature above stated, unless where clouds interpose, which operate as a screen in arresting the rays of heat. Dr. Wells seems to think, that the interposition of clouds operate not only as a screen in preventing radiation from the earth, but by actually radiating heat back to the ground, and thus restoring a portion of what had been formerly abstracted. This, we apprehend, may possibly take place when the clouds are low and dense, to which indeed Dr. Wells's remark chiefly applies; but, in general, their elevation is such, that their temperatrue must be lower than even the reduced temperature of the ground. But however this may be, the cold produced by radiation to a clear sky is sufficient to account for all the phenomena of dew. We have already seen, that the mean point of deposition in the atmosphere is about 6° below its mean minimum temperature, and that below this point it is no longer capable of holding its moisture in a state of solution. When the ground, therefore, is cooled down from 7° to 12° below the atmosphere, the portion of the latter in contact with the surface will in general be reduced below the point of deposition, and must consequently part with a portion of its humidity, the quantity deposited being proportional to the reduction of temperature, and the previous state of the air with regard to moisture. It appears accordingly from Dr. Wells's experiments, what might be inferred from the theory, that though of two similar substances examined at the same time, the coldest was always the most dewed, it did not uniformly happen, that on different nights, or even at different times of the same night, the quantity of dew was proportional to the reduction of temperature alone. "Thus during two nights," says Dr. Wells, p. 43, "on which grass was 12° or 14° colder than the air, there was little dew; while on the night which afforded the most copious dew ever observed by me, the cold possessed by the grass beyond that of the air was for the most part only 3° or 4°." It is deeply to be regretted, that in none of his experiments did Dr. Wells employ Leslie's hygrometer, the state of which, at the time of his observations, could not have failed to give them a precision which they can never otherwise possess.

The opinion which has sometimes been entertained, that dew is entirely produced by vapour emitted from the earth and vegetable substances, has been satisfactorily refuted by Dr. Wells, at least in so far as he has demonstrated, that a great proportion of it is deposited from the atmosphere. He has also examined, at considerable length, some of the objections that may be urged against his theory, and has thus been led to discuss various collateral subjects of considerable interest. But for these we must refer to the treatise itself. We would only observe, that the principle which he has assumed as the foundation of his theory, affords a satisfactory explanation of all the phenomena accompanying the production of dew, and that none of the apparent anomalies hitherto observed are sufficient of themselves to set that principle aside. It is in the adoption of this principle, indeed, that the chief merit of Dr. Wells consists, as many of the facts which he states had been previously made known by the experiments of Mr. Six of Canterbury, and Dr. Wilson of Glasgow.

When the *Essay on Dew* first made its appearance, it excited considerable interest in the scientific world, and for some time the accuracy of the theory there advanced seemed to be generally admitted. Of late, however, a very formidable attack has been made on the fundamental principle of that theory, and from a quarter which renders it particularly deserving of notice. Mr. Leslie, after having assigned to Dr. Wells "the merit of being the first who distinctly attributed the formation of dew to the previous cold induced on the ground from the aspect of the sky," and admitted that "this cooling of substances from exposure is at least one great source of dew," proceeds to express his regret, "that the explication of this primary phenomenon should have been sought for from the very loose, cumbrous, and visionary hypothesis, concerning what is gratuitously called *radiant heat*;" an hypothesis which he considers as "repugnant to all the principles of sound philosophy," and as "obtaining favour only from the blind admiration which the multitude are prone to entertain for whatever lulls the reasoning faculty, and appears cloudy and mysterious." The principle which Mr. Leslie proposes to substitute for radiant heat, in explaining the phenomena observed by Dr. Wells, is that of cold pulsations from the higher regions; but to do justice to the hypothesis, it will be necessary to state it in the author's own words. After explaining the diffusion of heat through the atmosphere, in a manner similar to the propagation of sound, he thus proceeds: "But the same pulsatory system will enable the atmosphere to transmit likewise the impressions of cold. The shell of air adjacent to a frigid surface becoming suddenly chilled, suffers a corresponding contraction, which must excite a concatenated train of pulsations. This contraction is followed by an immediate expansion, which withdraws a portion of heat from the next succeeding shell, itself now in the act of contracting; and the tide of apparent cold, or rather of deficient heat, shoots forwards with diffusive sweep."

Now it must appear obvious, we think, that upon this principle the frigorific pulses which Mr. Leslie supposes are showered down from the higher regions, never can communicate to the earth a greater degree of cold than they had previously communicated to the atmosphere. When the last pulsation reaches the surface of the ground, it will deposit its load of cold, if we may use such an expression, or abstract from the earth a quantity of caloric proportional to its reduction of temperature below that of the earth; but if the latter be the colder of the two, instead of abstracting, the shell of air will deposit heat, and tend to bring the ground to the same temperature with itself. The moment that the lowest film, or indefinitely small wave of air, comes in contact with a colder surface, it is precisely in the same circumstances with the highest one where the pulsation commenced; and should the temperature of the ground, therefore, be reduced by any means below that of the atmosphere, a concatenated train of pulsations ought, upon Mr. Leslie's principles, to commence at the surface of the earth, and proceed upwards till they arrive at a still colder region. Nor will it at all remove this objection, to say, that the pulsations from above more than counteract those from below, in consequence of the former being at a lower temperature than the latter. Admitting that the descending wave is the colder of the two, and not only arrests the progress of the other upwards, but actually propels it back again towards the earth, it still remains to be explained, how the surface of the ground comes to have its temperature reduced below that of the body by which it it is cooled, as was found to be the case by Dr. Wells and other observers. According to Mr. Leslie's theory, the atmosphere is not merely the medium by which the cold pulsations are conveyed, without having its own temperature affected by them. These pulsations are, in fact, the contractions which take place in the atmosphere itself, in consequence of the successive abstraction of caloric from each indefinitely thin film or stratum, so that the degree of cold which ultimately reaches the surface of the ground, can be nothing more than that to which the intermediate strata of the atmosphere had been previously reduced. If it be said, that these cold pulsations reach the earth without expending their cooling energy on the atmosphere, then we are at a loss to see any thing else in this than the "vulgar and unphilosophical" principle of *radiation*, or in what respects Mr. Leslie's theory differs from that of Dr. Wells, except that the latter ascribes the cold induced on the ground to the radiation of heat upwards, while the former explains it by the radiation of cold downwards. In whatever light Mr. Leslie's theory be viewed, it seems to be liable to much stronger objections than the one on which he has passed so severe a censure, and to which of the two the epithets of "cloudy and mysterious" may be justly applied, it is not very difficult we think to decide.

But it may perhaps be alleged, that the reality of frigorific pulses from a clear sky is established by the indications of an instrument lately constructed by Mr. Leslie, and to which he has given the name of Æthrioscope. This instrument is nothing more than the differential thermometer, placed in the hollow of an oblong spheroidal cup of brass or silver, having the sentient ball in the axis, and the other, which is covered with silver leaf, lodged in the cavity, and nearly in contact with the side of the cup. When the instrument in this state is freely exposed to the sky, the ball in the focus of the cup suffers a diminution of temperature, the enclosed air is contracted, and the liquid rises in the tube towards the ball, indicating a difference of temperature between the two balls, which in some cases amounts to 50 millesimal degrees. This effect is ascribed by Mr. Leslie to "an impression of cold shot downwards from the higher regions; but the phenomenon is just as easily accounted for on the principle adopted by Dr. Wells. The radiation of heat to the sky, from the sentient ball of the Æthrioscope, is augmented by that ball being placed in the focus of a metallic cup, which is itself radiating heat towards the same quarter, exactly as in the case of a heated body placed in the focus of a metallic reflector. Were the ball of the Æthrioscope exposed by itself, it would radiate heat only from the side directed towards the sky; but by being placed in the focus of the cup, radiation goes on from every point of its surface. This instrument therefore furnishes no additional support to Mr. Leslie's theory, nor does it at all militate against the commonly received opinion regarding the radiation of caloric. See our article COLD.

Various circumstances besides those already mentioned, occurred to Dr. Wells in the course of his experiments, which tend to confirm his theory of the production of dew. Thus he found that substances, as metals for example, which readily receive heat by conduction, but which radiate slowly, were, *ceteris, paribus*, less dewed than bodies possessing different qualities. He found also that grass, on a clear and still night, was uniformly colder than a gravel walk, evidently owing to the different quantities of heat which they received by conduction from the interior of the ground; and that on the same principle filamentous and downy substances become colder than all others. The influence of wind in preventing a reduction of temperature on the surface of the earth, even when the sky is clear, he ascribes not to its diminishing the quantity of radiation, but to its bringing successive portions of warmer air in contact with the ground, so that no dew can be formed till the whole of the air thus agitated is cooled down to the point of deposition. The same cause will account for less dew being deposited on mountains than on plains.

Some philosophers have ascribed the cold observed on the surface of the ground to evaporation, and there can be no doubt that, in certain circumstances, a considerable reduction of temperature may in this way be produced. We have frequently observed congelation going on in moist places during a brisk wind, while the temperature of the atmosphere at the height of a few feet was as high as 40°, and have more than once seen an icicle forming at the bulb of a moistened thermometer, while a contiguous dry one indicated a temperature of 38° or 39°. It is impossible, however, upon this principle, to account for many of the phenomena observed by Dr. Wells. If the cold were produced by evaporation alone, the difference between the temperature of the ground and that of the atmosphere near it, would diminish as the air became moist, and would disappear altogether when the latter was completely saturated. But the cold observed by Dr. Wells continued long after a deposition of moisture had taken place, and when not only evaporation must have ceased, but caloric must have been disengaged or become sensible, by the vapour passing into a liquid state. Besides, evaporation could have nothing to do with the reduction of temperature observed on substances exposed in a state of dryness, and not in contact with the earth.

When the temperature of the ground, after the deposition of moisture has taken place, is at or below 32°, the dew is congealed, and becomes *hoar frost*. According to the experiments detailed above, this may happen when the temperature of the atmosphere, a few feet above the surface, is considerably above 40°. We have often observed a copious hoar frost after a clear and calm night, though the minimum temperature, as indicated by a self-registering thermometer, had not been lower than 41° or 42°. The theory advanced by Dr. Wells satisfactorily explains this curious phenomenon, as well as the practical utility of the method frequently adopted by gardeners for preserving tender plants, by laying or suspending over them any covering, however thin, that serves to screen them from exposure to a clear sky.

We cannot conclude this article without expressing our regret, that the application of the principles developed by the researches of Leslie, Anderson, and Wells, has hitherto so seldom found a place in meteorological journals. To the laborious experiments and profound investigations of these eminent individuals the science has been deeply indebted; but it still remains for meteorologists to bring these discoveries to the test of daily observation, in order to confirm or correct the principles on which they are founded. In illustration of this remark, as well as of some other observations that have been made in the course of this article, we submit the following plan of a meteorological journal, which, though as extensive as any we have yet seen, still admits of some important additions and improvements.

Plan of a Meteorological Journal.

Year.	Thermometer.									Barometer.										
Mon.	Extr.		10.		Mean of			Daily Range.	Temp. spring water.	10 Mor.		10 Even.		Mean.		Day.		Night.		Range in 24 hours.
Date.	Max.	Min.	Morn.	Even.	Max. and Min.	10 and 10.	Both.			Temper.	Pressure.	Temper.	Pressure.	Temper.	Pressure.	Elevation.	Depression.	Elevation.	Depression.	

In examining meteorological tables, the difficulty of perceiving at once the extent of the fluctuations that take place in the temperature and pressure of the atmosphere is a frequent and just subject of complaint; and to remove this difficulty, a very simple expedient has been proposed, and is now frequently adopted. This method is represented in Plate CCCLXXIV. Fig. 10, where the horizontal lines denote the degrees of the thermometer, and the spaces between the vertical lines represent the days of the month. The extreme elevations and depressions of the instrument, or the points at which it stands at the hours of observation for every day, are marked on the diagram, and the line joining these points exhibits at one view the fluctuations of temperature. A similar diagram is employed to represent the elevations and depressions of the barometer. The necessity of this method however is, in some measure at least, superseded by entering in a separate column, as in the above plan, the daily range of both instruments. That of the thermometer is found by subtracting the maximum from the minimum, and an *approximation* to that of the barometer, by taking the difference between the observations at 10 morning and evening of the same day, which is entered in the 7th or 8th column, according as the mercury has risen or fallen, and also the difference between the observations at 10 on the evening of the one day and 10 on the morning of the following day, which is entered in the 9th or 10th column. The sum of these two differences is then carried to the last column, as the amount of the barometrical range for the whole twenty-four hours.

Hygrometer.																Wind.		Moon			Weather.	
Amount.		Leslie's.			Anderson's Formula.											By the clouds.		Mean Time.			General Remarks.	
					Point of Depos.			Quant. Moisture.			Rel. Humidity.											
Rain	Evaporation.	10 Morning.	10 Evening.	Mean.	10 Morn.	10 Even.	Mean	10 Morn.	10 Even.	Mean.	10 Morn.	10 Even	Mean.			Force.	Direction.	Phases.	Morning.	Evening.	Morning.	Evening.

The particulars in the above plan, which, as far as we know, are not to be found in any other table yet made public, are the results of Anderson's formula, as already explained, viz. the point of deposition, or the temperature at which the atmosphere would begin to deposit moisture; the actual quantity of moisture contained in 100 cubic inches of air, expressed in decimals of a grain; and the relative humidity, or quantity of moisture expressed in hundredths of what would produce complete saturation. In addition to these, however, it would be desirable, we think, to ascertain the following facts.

1*st*, The lowest point to which the temperature of the ground sinks during the night, and which might be found by exposing a minimum thermometer on the grass, and recording the result in the morning; and

2*dly*, The greatest depression of the hygrometer, both at the surface of the ground and a few feet above it, which might be ascertained by the self-registering hygrometer formerly explained. Were these instruments generally employed, every meteorological journal would exhibit a series of experiments, which could hardly fail both to give greater precision to the discoveries that have already been made, and to extend the boundaries of a science in which, from the want of accurate and uniform registers, there are still so many desiderata. See Arist. *De Meteor.* Arat. Dios. De Luc. *Idées sur la Meteorologie.* Forster *On Atmospheric Phenomena.* *Philosophical Transactions, Lond. and Edin* Leslie *On Heat and Moisture.* Playfair's *Outlines of Natural Philosophy.* Dalton's *Meteorology.* Wells *On Dew.* And our articles ATMOSPHERICAL CLOCK, BAROMETER, COLD, EVAPORATION, HYGROMETRY, PHYSICAL GEOGRAPHY, PNEUMATICS, THERMOMETER. &c. APPENDIX.

While the preceding article was preparing for the press, we were carrying on a series of observations with the sympiesometer, suspended in the same apartment with a very delicate mountain barometer. It may perhaps be gratifying to some of our readers to see the result of these, at the same time that they will shew on what grounds we formerly ventured to conjecture, that there might be something like absorption between the gas and the oil. Our observations commenced on the 4th of September, and were made generally twice a-day, with the most scrupulous attention to accuracy. We shall confine ourselves, however, to the observation at 10 in the morning.

Comparison of the Sympiesometer with the Mountain Barometer.

Sept.	Temper.	Barometer.	Sympiesometer.	Differ.	Octr.	Temper.	Barometer.	Sympiesometer.	Differ.
4	59 0	29.585	29 615	.030	7	54.2	29 550	29 640	.090
6	58.3	29 603	29.638	.035	8	53.5	29 840	29 930	.090
7	59 2	29.660	29 695	.035	9	57.3	29 555	29 625	070
8	60.8	29.832	29 880	.048	11	60.2	29 730	29.810	.080
9	62.2	29.890	29.940	.050	12	60.2	29.915	29.995	.080
10	61.8	30.012	30 060	.048	13	60 1	29.675	29 740	.065
11	59.4	30.160	30 215	.055	14	58.0	29.930	30.005	.075
13	60 3	30.075	30.125	.050	15	57.1	30.200	30 290	.090
14	61 0	30 085	30 130	.045	16	54 6	30.140	30.225	.085
15	62.6	29.855	29.910	.055	18	50.6	30.140	30.240	.100
16	57.5	29.760	29.810	050	19	52.8	29 835	29.935	.100
17	55 4	29.845	29 900	.055	20	53.7	29.360	29 450	.090
18	59 0	29 765	29.820	.055	21	48 2	29.452	29.560	.109
20	54.2	30.380	30.455	.075	22	46 2	29 300	29.425	.125
21	54 4	30 420	30.480	060	23	48 0	29.280	29.410	.130
22	54.0	30 383	30.455	072	25	44.2	29.652	29.805	.153
23	55 2	30 183	30 250	067	26	43 1	29 700	29.855	.155
24	56.2	29.815	29 890	.075	27	42.3	29.907	30.080	.173
25	57 6	29 505	29 570	.065	28	44.6	29.825	29.965	.140
27	55.7	29.250	29 320	.070	29	44.4	29.775	29.930	.155
28	55.4	29.190	29.250	.060	30	44.6	29.790	30.150	.160
Octr.					Nov.				
1	59.6	29.330	29.395	.065	1	42.8	29 890	30.040	.150
2	59 4	29.370	29.440	.070	2	43 4	29 595	29.740	.145
4	56 8	29 475	29 535	060	3	42 4	22.700	29 870	.170
5	52 0	29.882	29 965	.083	4	45 8	29.570	29.720	.150
6	53.8	29.420	29.500	.080	5	48.5	29.145	29.275	.130

It appears, from the above table, that the difference between the barometer and sympiesometer, which is always on the same side, generally increases as the temperature and pressure are diminished, though there are also instances in which this does not hold. This fact sufficiently explains what was observed by Lord Gray, and formerly noticed, that the difference between the two instruments, after progressively increasing for a time, began gradually to diminish; but it does not appear so easy to explain the fact itself. It could easily be shewn, indeed, from the law which regulates the elasticity and expansion of permanently elastic fluids, that however accurately the extreme points of the scale may be determined, if the intermediate space be divided into equal parts, the indications of the instrument cannot exactly coincide with those of the barometer under all pressures, and at all temperatures; but whether the error arising from this cause be sufficient to account for the differences in the above table, we shall not at present inquire. We would only remark, that though, in its present state, the sympiesometer cannot perhaps be relied on as an accurate measure of the weight of the atmosphere, its utility as a marine barometer is unquestionable. The instrument of this kind most valuable to the navigator, is that which is least affected by the ship's motion, and at the same time most sensible in indicating changes in the pressure of the atmosphere, without any regard to its absolute weight. With respect to the former, the superiority of the sympiesometer is too obvious to require being pointed out; and, with regard to delicacy, our own observations would lead us to infer that it is also superior to the mercurial barometer.

METHODISTS. A college of physicians who are said to have arisen at Rome in the days of Nero, and to have lasted 300 years, were called Methodistæ, from the regimen under which they put their patients. In the church of Rome, a species of polemical divines are called Methodists. In England the term Methodist, and Methodistical, is applied by way of sarcasm to the stricter professors of religion, although they may be regular members of the church of England, and never enter the doors of any conventicle. This use of the term is scarcely known in Scotland.

METHODISTS, as the distinctive appellation of a religious community, is now universally understood as designating the followers of the famous Mr. John Wesley. We indeed hear and read of *Calvinistic* and *Arminian* Methodists, the former being the followers of the Rev. George Whitefield, and the latter, of Wesley: but for many years the general term Methodist, as marking a sect of religionists, applies to those only who adopt the doctrine and discipline introduced by Mr. Wesley and his coadjutors. The Calvinistic Methodists or Congregationalists bear a near resemblance to the Puritans of a former age, being, generally speaking, deeper divines, and more systematically correct in their doctrinal opinions; for though they have no formula or creed, professedly, yet the books approved among them, and the account which members on admission give of their faith, plainly mark them as Calvinists at least of the Sublapsarian kind. But this article regards the Methodists as a distinct body, closely affiliated and known to each other in every quarter of the globe. In November, 1729, Mr. John Wesley being then a Fellow of Lincoln College, Oxford, Mr. Charles Wesley his brother, Mr. Morgan, Commoner of Christ Church, and Mr. Kirkman of Merton College, set apart some evenings for reading the original Scriptures and prayer. Some time after they were joined by Mr. Ingham of Queen's College, Mr. Broughton of Exeter, and Mr. James Hervey; and in 1735, by the celebrated Mr. George Whitefield. They soon began to leave occasionally the more private fellowship meeting, to visit the prisoners in the castle, and the sick poor in the town. They also instituted a fund for the relief of the poor, to support which they abridged all superfluities, and even many of the comforts of life. Their private meetings became more and more of a religious character. They observed the fasts of the ancient Church every Wednesday and Friday, and communicated once a-week. "We were now," says Mr. Wesley, "fifteen in number, all of one heart and of one mind." Their strict deportment soon attracted the attention of the college censors and students, who branded them with many opprobrious epithets, such as Sacramentarians, the Godly Club, and afterwards *Methodists.* The sneers of the young men they seem to have regarded little; but when some of the seniors of the University were offended, Mr. John Wesley wrote to his father, the venerable Rector of Epworth, and to other gentlemen of learning and piety, for advice. The following sentences from his father's answer will shew his spirit. "And now as to your designs and employments, what can I say less of them than *valde probo*; and that I have the highest reason to bless God, that he has given me two sons together at Oxford, to whom he has given grace and courage to turn the war against the world and the devil, which is the best way to conquer them; they have but one more enemy to combat with, *the flesh.* I think I must adopt Mr. Morgan to be my son with you, and your brother Charles; and when I have such a ternion to prosecute that war wherein I am now '*Miles Emeritus*, I shall not be ashamed when they speak with their enemies in the gate.' When I was an under graduate I visited those in the Castle there; and reflect on it with pleasure to this day. Walk as prudently as you can, but not fearfully, and my heart and prayers are with you." Whatever effect obloquy might have upon some of the members of this select class, Mr. John Wesley, as well as his brother, and several others, remained unshaken. He puzzled his opponents with questions concerning the reasonableness of his conduct. He did more; he confounded them by an uniform regularity of life, and an astonishing proficiency in his studies. Mr. Morgan, one of the most active members, was soon after this removed by death; occasioned, according to the representation of enemies, by fasting and excessive austerities; a very uncommon cause of dying at Oxford, or any where else. His character was drawn by Mr. Samuel Wesley, junr. in a poetic tribute to his memory, under this text, from the book of wisdom, "We fools accounted his life madness." In the spring of 1735, Mr. John Wesley was called to attend his dying father, who desired him to present to Queen Caroline, a book he had just finished. Soon after his return to Oxford, he went to London on this account, where he was strongly solicited by Dr. Burton, one of the trustees for the new colony at Georgia, to go there to preach to the Indians. At first he peremptorily refused. He particularly mentioned the grief it would occasion to his widowed mother. The case being referred to her, she is said to have made this reply: "Had I twenty sons, I should rejoice that they were all so employed, though I should never see them more." His way appeared now plain; and he made arrangements for this enterprize. On Tuesday, October 14, 1735, he set off from London for Gravesend, accompanied by Mr. Ingham, Mr. Delamotte, and his brother Charles, to embark for Georgia. There were six-and-twenty Germans on board, members of the Moravian church, with whose Christian deportment Mr. Wesley was much struck, and immediately set himself to learn the German language, in order to converse with them. The Moravian Bishop, and two others of his society, began to learn English. He now began to preach extempore, which he afterwards made his constant practice during his life, and yet he wrote much.

The piety and devotion which Mr. Wesley and his companions manifested during the voyage was highly commendable, and indicated a becoming impression of the importance of their undertaking; but, owing to some disagreeable circumstances, Mr. John Wesley returned to England without having made much progress in the proposed object, and was succeeded by his valued friend Mr. George Whitefield, who arrived at Savannah on the 7th May 1738, and was received by Mr. Delamotte, and many of Mr. Wesley's hearers. It may be proper to notice the success which attended Mr. Whitefield's labours in this quarter of the globe. He laboured with great zeal, and was honoured to be useful. He returned to England in the close of the same year to receive priest's orders. On his return to America in 1739, he landed at Philadelphia, and immediately began his spiritual labours, which he continued as he passed through the colonies of Virginia, Maryland, and North and South Carolina, being attended by considerable audiences. Upon his arrival at Savannah, he found the colony almost deserted, which moved him to carry into effect his scheme of building an orphan-house, which he had the happiness to see completed through his exertions, and the liberal donations of his friends. Upon his third visit to the western continent, he took a voyage to the Bermudas Islands, where his ministry was successfully attended, and some contributions made for his orphan-house at Savannah. Upon his sixth voyage to Georgia, he received the thanks of the governor and principal people, for the advantage which the colony had derived from his benevolent exertions, a circumstance which tends greatly to vindicate the character of this singular man, from the very unjust reproach of avarice which was frequently thrown upon him. In 1769, he made his 7th and last voyage to America; but, although his labours were so extensive, he formed no separate congregations. In the intervals of his visits to America, he frequently made tours to Scotland and Ireland, where he attracted numerous assemblies, and always made a powerful impression by his eloquence; but having differed in doctrinal sentiment from Mr. Wesley, and never having formed the idea of a separate association of itinerants and of members, he can scarcely be considered as the head of any party. Mr. Wesley is the father of the Methodists, of whose rise, progress, doctrine, and discipline, we shall now give a very brief account.

Upon Mr. Wesley's return to England, he was invited to preach in several churches, but the concourse of people who followed him was so great, that the churches in general were shut against him. His converts now began to form themselves into a little society, as he and his companions had formerly done at Oxford. They then agreed that they would meet together once a week, "to confess their faults one to another, and pray one for another; that the persons so meeting should be divided into several *bands*, or little companies, none of them of fewer than *five*, or more than *ten* persons; that every one in order should speak as freely, plainly, and concisely as he could, the real state of his heart, with his several temptations and deliverances since their last meeting;—that all the bands should have a conference at eight every Wendesday evening, begun and ended with singing and prayer;—that any who desired to be admitted into this society should be asked, What are your reasons for desiring this? Will you be entirely open, using no kind of reserve? Have you any objection to any of our orders? That after two month's trial, they should be admitted into the society;—that every fourth Saturday should be observed as a day of general intercession;—that on the Sunday se'ennight following, there should be a general *love feast* from seven till ten in the evening;—that no member should be allowed to act in any thing contrary to any order of the society; and that if any persons, after being thrice admonished, should not conform thereto, they should no longer be esteemed as members. Here we have the platform of the system of Methodism. It was still Mr. Wesley's desire and design to preach in the established church, and it is remarkable that he always considered himself a member of it. His plan seems to have been to promote a reformation in the church, instead of separating from it. The rules he observed himself and recommended to his followers seem to have been designed as supplementary to the accustomed ceremonial. He is, without seeming to have intended it, the founder of the most numerous and remarkable religious sect of which we have any account in ancient or modern times.

It must be acknowledged, however, that the doctrine Mr. Wesley taught is not strictly according to the thirty-nine articles.

The Methodists are professed Arminians. They deny the doctrines of *election*, and the certainty of the saints' perseverance.

In regard to original sin, and the extent of human inability, it is not so easy to say what are their precise opinions. They seem to hold, that the effect of the mediation of Christ in regard to all men is, that they may, by the use of the means put in their power, secure their salvation. They certainly go very far in asserting the attainableness of *perfection* in this life. They ground their doctrine on this subject upon such texts as these: "Be perfect." "Herein is our love made perfect, that we may have boldness in the day of judgment, because as he is, so are we in this world."* It is proper farther to notice, that while they deny, as above mentioned, the doctrine of *election* as taught by the Calvinists, they hold that *certain* persons and churches have been elected, and that *great* events are fore-ordained. It is affirmed by respectable authority, that when Mr. Wesley preached in Scotland, he was more cautious in expressing his sentiments on this subject, knowing the Calvinistic creed of the Scottish people. Whatever may be in this, it is certain that his modern followers have not always been so accommodating. Of late years many of their most eminent preachers have brought forward their opi-

* It is a question put by their class leaders, "Have you power over all sin?"

nions on these points with much zeal, and even in a controversial form. Certain it is, however, that the Methodists never have made much progress in North Britain, owing to the hold which the doctrine of the Westminster Confession has upon the minds of the Scotch people, and, it is but fair to add, owing to the residence of the clergy, and the decorous character of the people in general, which may be supposed to make them less accessible to the impressions of terror, one of the chief of the means by which the Methodists aim at operating upon the minds of men. It may also be added, that the minute inspection which the laws of Methodism authorize, as to the very feelings and private exercises of each individual, does not accord with the taciturn, prudent, and independent genius of our people; and perhaps the levy of one shilling quarterly, for the renewal of tickets to constitute full membership, may operate in part as an obstruction. Of late, it became a matter of conference whether Scotland should be relinquished, as bearing heavy on the funds of the society, or whether greater exertions should be made. The latter alternative was adopted; and by employing some of their most eloquent preachers, by erecting better places of worship in more prominent situations, and their usual attention to the cultivation of vocal music, they may perhaps gain their object, unless similar means are employed by the Presbyterians, and more accommodation provided in our large towns for the increasing population. When we look to England and Wales, and the New-World, we see the triumphs of the Methodists. Their numbers are very great, and every year increasing. By the account of the 76th annual conference, held at Bristol in July 1819, it appears that no fewer than 6905 have been added to their society during the past year; that in Great Britain they have 318 stations, each employing at the least two preachers, and in chief towns three or four; in France, they have four missionary stations; in Gibraltar, one; in Brussels, one; in Ceylon and continental India, upwards of twenty missionaries; in Africa six, and more requested; in the West Indies, upwards of forty; in the British provincess of North America, (where the Church of Scotland has done so little,) the Methodists have forty-five preachers.

For their zealous exertions in the conversion of the negroes in the West Indies, in which Dr. Coke, lately deceased, laboured so indefatigably, the Methodists deserve well of the Christain world. Indeed, had it not been for them, our countrymen in these islands would have had scarcely any opportunities of Christian instruction and public worship. As yet they are the chief labourers in British America.

There have been, from time to time, partial separations from the methodists, concerning the administration of the sacraments, service in church hours, &c. but the most formidable divisions have been those relative to the nature and exercise of religious liberty, and to the forms of church government. Disputes on these subjects have produced the *Methodist New Itinerancy*, and the Society of *Revival Methodists*. At the head of the former was Mr Alexander Kilham, who published a book, entitled *the Progress of Liberty among the People called Methodists*, in which he exposed the alleged defects of the "Old Plan," and proposed a form of church government on a broad and liberal basis. He argued, that the whole power of church government was engrossed by the preachers, and that the people were not represented in the meetings of conference, in other words, their *General Assembly*. We cannot pronounce on the merits of the question. When the conference assembled, Mr. Kilham was *unanimously* expelled the connection. The minutes of the trial were published, and every preacher signed his name to a paper, testifying his approbation of the sentence. A declaration of allegiance to the conference (held at Leeds, July 31, 1797,) was drawn up, which was signed by all the preachers present, excepting Messrs. Thom and Eversfield; a third, Mr. Cummin, signified his dissent by letter, "They (says Mr. Myles, in his *History of the Methodists*,) joined Alexander Kilham, and made a schism, under the name of *the New Itinerancy*." The division thus originating amounted to about five thousand. In the year 1806 they had nineteen circuits, thirty travelling or circuit preachers, and about sixty local preachers. They purchased a large and elegant meeting house, called Gibraltar Chapel, in Church Street, where there is an extensive burial ground. The Revival Methodists form a numerous body of the Wesleyan Christians. They are not, however, all of them formally separated from the old connection, though they have, in many towns, separate places for religious worship. In Manchester, Liverpool, Leeds, Stockport, Preston, and Macclesfield, they are numerous. In the latter place they have lately built a neat chapel, having been long separated from the old connection. They have published their rules in a small pamphlet, entitled "*General Rules of a Society of Christian Revivalists at Macclesfield*, with a preface, containing a declaration of doctrines." They are distinguished chiefly, by their claiming as a Christain privilege a right to indulge their feelings as to prayer and praise at all times, and on all occasions,—for example, while the minister is engaged in preaching. No idea can be formed of their number, as they are diffused, more or less, among the general body of methodists.

We are unwilling to pronounce upon the comparative value of Methodism, and the evils which have more or less accompanied it. The enemies of the Methodists say, they have contributed to fill the asylums of lunacy; whereas it is beyond question, that they have in a thousand instances been the means of reclaiming the most vicious and depraved characters. They have been regarded as the most formidable enemies of the establishment; but they have done much good among many who might never have sought more connection with the church, than to procure baptism, marriage, and burial. It is certain they are, generally speaking, good members of society, and very peaceable subjects. They are in general temperate, both in food and dress. They avoid all places of public amusement. They are very kind and sympathizing to their poor and distressed members. *They make a business of religion* more than the generality of Christain professors. Impartiality requires that we just hint at the defects and errors prevalent among them. If we judge from the Monthly Magazine, edited by one of their most respectable members, it is undeniable that too many of their members are guided in their determinations by feelings and impressions: that they are too apt to magnify common events as bordering on the miraculous: that their fixing always the day, and even the moment of conversion, endangers presumption on the one hand, or distracting fears on the other; that their regular detail of each individual's experiences and inward conflicts, seems neither rational nor scriptural, and leads to many errors; and that the practice of lay preaching is apt to expose the work of the Evangelist to contempt. Moreover, their system of itinerancy, and circulation of preachers, which is one of the most striking features of their whole plan, seems not to accord with the Scriptural descriptions of the relation between pastor and flock, and encourages a superficial religion, instead of Christain edification. But what Mr. Wesley said of himself, may be regarded as applicable to most of the preachers of his connexion—"I know, were I myself to preach one whole year in one place, I should preach both myself and most of my congregation asleep."—"We have found, by long and constant experience, that a frequent change of teachers is best." Upon the whole, Methodism seems better calculated to rouse the careless, than to build up believers:—to stimulate the zeal of the Christian world, than to form or regulate churches:—to excite men to seek spiritual food, rather than regularly to administer it. Let Methodists learn from the pious members of the establishments, more regard to order, and to sober mindedness; but let all the churches learn from *them*, more fervour in devotion, more blamelessness of conduct, more brotherly affection, and a conversation which becomes the Gospel. Wesley's *life by Coke and Moore.* Myles' *History of the Methodists. Christian Observer*, vol viii. *Arminian Magazine. Quarterly Review.* Wesley and Coke's *Journals.* Fletcher of Madeley's works, entitled *Checks to Antinomianism, &c.*

MEURTHE, the name of one of the departments in the north-east region of France, and one of the richest in the kingdom. It is bounded on the north by the department of the Moselle, on the west by the *Netherlands*, on the south by that of the Vosges, and on the east by that of the Lower Rhine. It is watered by the Meurthe, (from which it derives its name,) which runs into the Moselle below Frouard, and also by the Seille, the Sarre, and the Vezouze, which flows into the Meurthe at Luneville. Its principal productions are, corn, wines, tobacco, hemp, madder, saffron, wood of construction, iron mines, and salt springs. In the arrondissement of Luneville there are several glass-works, particularly those of St. Quirin. Phalsbourg, in the arrondissement of Sarrebourg, is celebrated for its liqueurs. Chateau-Salins derives its name from the salt-springs which prevail there. Dieuze, in the same canton, has likewise salt-springs. In the middle of a marsh in the neighbourhood of Nanci, an obelisk marks the place where Charles the Bold perished. In the neighbourhood of Toul, earthen ware is manufactured. The following are the principal towns, with their population.

Nanci (the capital)	29,740
Luneville	9,797
Toul	6,949
Chateau-Salins	2,110
Sarrebourg	1,454

Luneville, situated between the Vezouze and the Meurthe, is celebrated for the treaty signed at it in 1801, between France and Austria. It has an academy and a good library.

The department contains 6430 square kilometres, or 325 square leagues. The forests amount to about 227 sectores, or 445 thousand acres, of which nearly 100 thousand belong to the government, 65 thousand to the communes, and the remainder to individuals. The contributions in the year 1801 amounted to 2,681,581 francs. Population 342,107.

MEXICO.

Mexico, (town of,) the capital city of New Spain, is situated in 19°, 25', 45" of north latitude, and 99°, 5', 15" of west longitude, 7470 feet above the level of the sea. Its name imports, in the Aztec language, the habitation of the god of war; but, before the year 1530, it was more commonly called Tenochtitlan, which Cortez corrupted into Temixtitan. Its situation on an isthmus, washed by the South Sea and the Atlantic Ocean, is peculiarly favourable for commercial communications; but the state of the coast, and the want of ports on the Atlantic, oppose great obstacles to its prosperity. It stands in the midst of a fine valley, about 70 leagues in circumference, and was formerly surrounded by a salt-water lake, and intersected by navigable canals. It was accessible by means of three dikes, or causeways, about 20 feet in breadth, which were carried through the lake, for the space of more than a league, in different directions. But the water of the lake, which seems to have begun to decrease long before the arrival of the Spaniards, is above two miles distant from the city in its present state. The city was almost completely destroyed at its conquest by Cortez, by whom it was rebuilt on the same spot, so that the present streets have for the most part the same direction as the old ones, running nearly from north to south, and from east to west, forming a great square, of which each side is nearly 9021 feet in extent. In its ancient state, surrounded with water, and founded on islands covered with verdure, the capital of Mexico must have resembled some of the cities of China or of Holland. It is still one of the finest cities ever built by Europeans, and is surpassed by few towns, even on the old continent, for the uniform level of the ground on which it stands, the regularity and breadth of the streets, and the extent of the public places. The houses, built of hewn stone, (which is a porous amygdaloid, or a porphyry of vitreous feld-spath,) have a great appearance of solidity and magnificence. They are not loaded with ornaments, and have none of those wooden balconies and galleries which so much disfigure the European houses in both the Indies. The balustrades and gates are all of Biscay-iron, ornamented with bronze; and, instead of roofs, there are terraces resembling those of Italy and other southern countries. The architecture in general is of a very pure style; and there are several edifices of a very beautiful structure. Those which usually attract the attention of a stranger, are the *cathedral*, a small part of which is in the Gothic style, and the principal edifice, which is of recent date and fine proportion, has two towers, ornamented with pilasters and statues; the *treasury*, adjoining to the palace of the viceroys; the *convents*, particularly that of St. Francis; the *hospital*, which maintains 1400 children and old people; the *acordada*, a fine edifice provided with spacious and well aired-prisons, capable of containing more than 1200 individuals; the *school of mines*, a beautiful new building, which contains fine collections in physics, mechanics, and mineralogy; the *botanical garden*, small, but rich in the more rare and interesting vegetable productions; the *university public library*; the *academy of fine arts*; the *equestrian statue* of Charles IV. in the Plaza Mayor; and the *sepulchral monument* to Cortez, in a chapel of the Hospital de los Naturales. The town has been much embellished since the year 1769. Two great palaces or hotels have been recently constructed by Mexican artists from the academy of the arts in fine captial, one of which, in the interior of the court, exhibits a very beautiful oval peristyle of coupled columns. But it is the extent and uniform regularity of the city, and the breadth and straightness of the streets, more than the grandeur or number of its monuments, which excite admiration; while the excellence of the police preserves every thing in proper order and repair. Most of the streets have very broad pavements, and are both clean and well lighted. The supply of water is well regulated; and, as that which is found by digging is of a brackish quality, spring water is conveyed from a considerable distance by means of two aqueducts of modern construction, which are well worthy of notice. One of them, leading from the insulated hill of Chapoltepec, is carried upon arches for the space of 10,826 feet, and the other from the Cordillera, which separates the valley of Mexico from that of Lerma and Toluca, is about 33,464 feet in length, but, on account of the declivity of the ground, is conducted over arches for no more than a third part of the space. The ancient dikes, or causeways, still exist; and others have been formed across the marshy grounds, which at once serve the purposes of roads for carriages, and of mounds to resist the overflowings of the lake. There are few remains of Mexican antiquities to be found in the capital. The ancient temples, or teocallis, which were truncated pyramids, with a broad base, and frequently 150 feet in height, covered with wooden cupolas and altars, were so much used during the siege as places of defence, that most of them were destroyed in its progress, and the rest afterwards thrown down, partly as being heathen monuments displeasing to Popish bigotry, and partly as furnishing strong-holds to the Indian insurgents. The few remaining relics of Mexican art are the dikes and aqueducts; the stone of the sacrifice; the great calendar monument; the colossal statue of the goddess Teoyaomiqui, which lies covered with a few inches of earth in one of the galleries of the university; the Aztec manuscripts, or hieroglyphical pictures, painted on agaue paper, stagskins, and cotton cloth, which are preserved rather carelessly in one of the archives of the viceroy's palace; the foundations of the palace of the kings of Alcolhuacan at Tezcuco; the colossal relievo, traced on the porphyritical rock called Penol de los Banos; with several other objects, which are considered as resembling the works of the ancient Mongol race.

The population of Mexico, according to the most recent and certain data, amounts to not less than 135,000, or 140,000, including the military, who are seldom fewer than 5000 or 6000. According to M. Humboldt, the whole may be classed under the following heads—

White Europeans . . .	2 500
White Creoles	65,000
Indigenous, (copper coloured) .	33 000
Mestizoes, mixture of Whites and Indians	26,000
Mulattoes	10,000
	136,500

There are 23 male convents, containing about 1200 individuals, of whom 580 are priests and choristers; and 15 female convents, containing 2100 individuals, of whom nearly 900 are professed religieuses. The market of Mexico is abundantly supplied with provisions, particularly with roots and fruits of every description; which may be seen every morning at sunrise brought down the canals in boats by the Indians, along with a great quantity of flowers. The greater part of these roots are cultivated on the chinampas, or floating gardens, in the adjoining lakes. These gardens are known to have been in use as far back as the end of the 14th century, and are supposed to have been suggested by the natural occurrence of small portions of earth covered with herbs, and bound together by their roots, detached from the banks, and floating on the surface of the water, or sometimes uniting together so as to form small islands. They were afterward artificially constructed, by making rafts of reeds, rushes, roots, and brushwood, covering these with black mould, naturally impregnated with muriate of soda, but gradually purified from the salt, and rendered fertile by washing it with the water of the lake. Some of these gardens are moveable, and driven about by the winds; but others are anchored, or attached to the shore, and are towed, or pushed with poles from one spot to another. Frequently a cottage is built upon them for the residence of an Indian, who acts as keeper or guard for a whole group. They are usually 328 feet in length, by 16 or 19 in breadth, rising about 3 feet above the surrounding water; but many of them have now become fixed, lying along the canal, and separated from each other by narrow ditches. The edges of these squares, formed in this manner, are generally ornamented with flowers, and sometimes with a hedge of rose-bushes. On a soil thus constantly refreshed with water, the vegetation is extremely vigorous; and a great variety of vegetables, particularly beans, peas, pimento, potatoes, artichokes, and cauliflowers are raised upon them.

The town of Mexico is scarcely less endangered by inundations than that of Lima by earthquakes; and in every 20 years, at least, has been greatly injured by the overflowing waters of the neighbouring lakes. All these lakes, except that of Tezcuco, are on a higher level than the city; and even the bed of this nearest lake is progressively rising by the accumulation of mud, while the paved streets of Mexico remain a fixed plane. These inundations occasioned less inconvenience in the old city, when the inhabitants were accustomed to live much in their canoes, and when the houses were so constructed, that boats could pass through the lower story. But the losses experienced in the modern city were much greater, and more alarming to the inhabitants, who have been obliged to abandon the old Indian system of dikes or mounds, which were found insufficient to repel the floods, and have adopted the plan of canals of evacuation to carry off the superabundant waters. At one period, in consequence of these works being interrupted, Mexico remained inundated for five years, from 1629 to 1634. The greatest wretchedness prevailed among the lower orders; all commerce was at a stand; and it was only by frequent earthquakes opening the ground of the valley that the waters were removed. At length, after various schemes and delays, an immense outlet through the mountains to the north-east was completed in 1789, called the Desague de Hue-buetoca, which is one of the most gigantic hydraulic operations ever executed by man, and which, if filled with water to the depth of 32 feet, would allow the largest ships of war to pass. The canal is more than four leagues and a half in length; and a fourth part of the whole is cut through the hills of Nochistongo. For the space of 11.482 feet, the depth of the cut is from 98 to 131 feet; and at the highest part of the ridge, for the space of 2624 feet, the perpendicular depth is not less than from 147 to 196 feet, while the breadth at the top is from 278 to 360 feet. But, in spite of all the means which have been used to secure the capital against inundation from the north and north-west, it is still exposed to great risks from the adjoining lake of Tezcuco, for the draining of which a canal is begun to be executed, which will extend above 104,660 feet, and cost £125.000. These operations have proved fatal to multitudes of Indians, who are compelled to labour in the public works to the neglect of their own domestic affairs; and who, besides perishing in great numbers from disease and casualties, are reduced to a general state of poverty.

The environs of Mexico present a rich and varied appearance, when viewed in the morning from the towers of the cathedral, or the hill of Chapoltepec. The eye, (says M. Humboldt,) sweeps over a vast plain of carefully cultivated fields, which extend to the very feet of the colossal mountains covered with perpetual snow. The city appears as if washed by the waters of the lake Tezcuco, whose basin, surrounded with villages and hamlets, brings to mind the most beautiful lakes of the mountains of Swisserland. Large avenues of elms and poplars lead in every direction to the capital; and two aqueducts, constructed over arches of very great elevation, cross the plain, and exhibit an appearance equally agreeable and interesting. The magnificent convent of Neustra Sonora de Guadalupe appears joined to the mountains of Tapeyacac, among ravines, which shelter a few dates and young yucca trees. Towards the south, the whole track between San Angel Tacabaya, and San Augusta de las Cuevas, appears an immense garden of orange, peach, apple, cherry, and other European fruit-trees. This beautiful cultivation forms a singular contrast with the wild appearance of the naked mountains, which inclose the valley, among which the famous volcanos of Puebla Popocatepetl, and Iztaccicihuatl are the most distinguished. The first of these forms an enormous cone, of which the crater, continually inflamed and throwing up smoke and ashes, opens in the midst of eternal snows." See Robertson's *History of America*, and Humboldt's *Essay on New Spain*. (*q*)

MEXICO, or New Spain, is one of the nine great governments into which the Spanish possessions in America are divided; and is by far the most important of them all, both on account of its territorial wealth and its favourable position for commercial communications. Its Indian name, Mexico, signifies, in the Aztec language, the habitation of the god of war; and the designation of New Spain, first applied in 1518 to the province of Yucatan, and afterwards to the whole empire of Montezuma, now includes all the extent of country over which the viceroy of Mexico exercises his authority, lying between the 10th and 38th degrees of north latitude: but the kingdom or captain-generalship of Guatimala, is considered a distinct government, and is generally excluded from the proper territories of Mexico. In this more limited view, then, the kingdom of New Spain extends from the 16th to the 38th degree of north latitude, about 610 leagues in length, and 364 at its greatest breadth. One half of its whole surface is situated under the burning sky of the tropics, and the other under the temperate zone: but, from the singular elevation of the ground above the level of the sea, nearly three-fifths of the country under the torrid zone enjoy a temperate instead of a sultry climate. The whole interior of the viceroyalty of Mexico forms one immense plain, elevated from 6560 to 8200 feet above the level of the neighbouring seas, extending from the 18th to the 40th degree of north latitude. The descent from this central table land towards Acapulco, on the west coast, is a regular progress from a cold to a hot climate, by a road which may be made fit for carriages: while, on the east coast to Vera Cruz, the descent is short and rapid, passable only by mules, but likely to be soon rendered accessible for carriages, by the construction of a superb causeway, which was begun about the commencement of the present century. From Mexico to New Biscay, the plain preserves an equal elevation, and lies under a climate rather cold than temperate; and it is only the coasts of this vast kingdom which possess a warm climate, adapted for the productions of the West Indies. The mean temperature of these plains, which are situated within the tropics, and not more than 984 feet above the level of the sea, and which are called by the natives Terras Calientes, is about 77° of Fahrenheit. On the eastern coast, the great heats are occasionally interrupted by strata of cold air brought by the winds from Hudson's Bay, from October to March, and which frequently cool the atmosphere to such a degree, that the thermometer of Fahrenheit stands at 60° at Vera Cruz; but, on the western coast, in the town and neighbourhood of Acapulco, the climate is the hottest and most unhealthy in the world. On the declivity of the Cordillera, at the elevation of 3930 to 4920 feet, there prevails perpetually a soft spring temperature, seldom varying more than seven or nine degrees, and where the extremes of heat and cold are equally unknown. This region is called the Tierras Templadas, in which the mean temperature of the whole year is from 68° to 70° of Fahrenheit; but the clouds, which ascend above the lower plains, usually settle on this height, and occasion frequent thick fogs. The third zone, called Terras Frias, comprehends the plains which are elevated more than 7200 feet, and of which the mean temperature is under 62°. In the plains which are still more elevated, even to the height of 8200 feet, the climate, even within the tropics, is rude and chill, the heat during a great part of the day never rising to more than 51° or 55°. The winters here are not indeed extremely boisterous; but the sun, even in summer, has not sufficient power in the rarefied atmosphere to accelerate vegetation and bring fruits to maturity. In general, the equinoctial regions of New Spain resemble the temperate zones in soil and climate, and vegetation; but, in the central table land, the temperature is extremely cold in winter. The region of perpetual snow in the 19th and 20th degrees of latitude, commences at about 15,000 feet of elevation; and, in the month of January, descends to about 12,000; but there are occasional falls of snow between the parallels of 18 and 22 at the height of 9840 feet, and even the towns of Mexico and Valladolid, which are more than 200 and 300 feet lower. From the 22° to the 30° of north latitude, the rains fall only in the months of June, July, August, and September; but, even then, are not frequent in the interior of the country. The declivities of the Cordillera are exposed to humid winds and frequent fogs; and the sea coasts receive immense quantities of rain from the month of June to September. With the exception of a few sea ports and deep vallies, where intermittent fevers prevail, the climate of New Spain may be accounted remarkably salubrious.

On each coast, the low grounds are intersected by very inconsiderable hills: but, in the central plain, between the town of Mexico and the city of Cordova, there are groupes of lofty mountains, equal in height to any in the new continent, particularly those of Popocatepetl, *i. e.* the smoke mountain, Iztaccihuatl, *i. e.* the white woman, Citlaltepetl, *i. e.* star mountain or the Pic d'Ouzaba, and Nauhcampatepetl, *i. e.* square mountain, or the Cofre de Perote, which are respectively 17,716, 15,700, 17,371, and 13,414 feet above the level of the sea. To the north of latitude 19° the Cordillera takes the name of Sierra Madre, and runs to the north-west. Beyond the city of Guanaxuato, in latitude 21°, it becomes of an extraordinary breadth, and divides into three branches. Of these the most eastern runs in the direction of Charcas, and loses itself in the new kingdom of Leon. The western branch, occupying part of the intendancy of Guadalaxara, sinks rapidly after psssing Bolanos, and stretches to the banks of the Rio Gila, but acquires again a considerable height under the 30th parallel, near the Gulf of California, when it forms the mountains de la Pimeria Alta, celebrated for the gold washed down from their sides. The third branch, which may be considered as the central chain of the Mexican Andes, occupies the whole extent of the intendancy of Zacatecas, and may be traced to the Sierra de los Mimbres, west of the Rio Grande del Norte, thence traversing New Mexico, and joining the Crane mountains and Sierra Verde. This central branch is the crest which divides the waters between the Pacific and Atlantic oceans; and it was a continuation of this branch which Fidler and Mackenzie examined under the 50° and 55° of north latitude.

There are five burning volcanos in Mexico, namely, Ouzaba, Popocatepetl, Tustla, Jorullo, and Colinia; but earthquakes and eruptions are not frequent. The former are chiefly experienced on the coast of the Pacific, and in the environs of the capital, but never produce such desolating effects as in the provinces of Guatimala, Cumana, Quito, and Lima.

In New Spain there is a great want of water, and of navigable rivers. The great river of the north (Rio Bravo del Norte) and the Rio Colorado, are the only rivers distingushed by the length of their course, and their volume of water. The first of these runs through a course of 512 leagues from its source in the mountains of Sierra Verde, east from the lake of Timpanogos, to its mouth in the province of New Santander in the Gulf of Mexico; and the latter flows 250 leagues from its origin in a hilly tract, about 13 leagues west from that of the del Norte, till it falls into the Gulf of California. This last mentioned river is formed by the union of the Zauganames and the Nabajoa; and itself forms a junction with the Gila about the 32d parallel of north latitude. In the southern part of Mexico, the narrow form of the continent prevents the collection of a great mass of water, and the rapid declivity of the Cordillera abounds in torrents rather than rivers. Those which are most adapted for navigation are, the Guasacualco and the Alvarado to the south-east of Vera Cruz; the Moctezuma, which carries the waters of lake Tenochtitlan to the Panuco; the Zacatula, at a small sea-port of the Pacific Ocean on the frontiers dividing the intendancies of Mexico and Valladolid; and the great river of Santiago, formed by the junction of the Lerma and Laxas, and falling into the South Sea at the port of San Blas.

The lakes, with which Mexico abounds, are considered as merely the remains of immense basins of water, which appear to have formerly existed on the high plains of the Cordillera, and are said to be annually diminishing. The most remarkable are the great lake of Chapala in New Gallicia, nearly 160 leagues square; the lakes in the valley of Mexico, which cover a fourth part of the district; the lake of Patzcuaro in the intendancy of Valladolid, which is accounted one of the most picturesque situations in the world; the lakes of Mextitlan and Parras in New Biscay; and the great lake of Nicaragua, about 200 miles in circumference, in the kingdom of Guatimala.

The mineral productions of this country form one of the principal sources of its wealth, and are found in a great variety of rocks and forms throughout the range of the Cordilleras; but the districts of Guanaxuato, Zacatecas, and Catorce are the most abundant, and supply more than one half of the whole amount of precious metals exported from the country. The former alone yields one-fourth of the silver of Mexico, and one-sixth of the produce of all America. The richest mines of New Spain, arranged according to the quantity of metal which they yield, are

Guanaxuato, in the intendancy of the same name.
Catorce, in the intendancy of San Louis Potosi.
Zacatecas, in the intendancy of the same name.
Real del Monte, in the intendancy of Mexico.
Bolanos, in the intendancy of Guadalaxara.
Guarisamey, in the intendancy of Durango.
Sombrerete, in the intendancy of Zacatecas.
Tasco, in the intendancy of Mexico.
Batopilas, in the intendancy of Durango.
Zimapan, in the intendancy of Mexico.
Fremillo, in the intendancy of Zacatecas.
Ramos, in the intendancy of San Louis Potosi; and
Parral, in the intendancy of Durango.

The Mexican mines are considered as forming eight groupes, &c. and are almost all placed either on the ridge or the western slope of the Cordillera of Anahuac; and it is a remarkable circumstance, that the tract which yields the greatest quantity of silver, between 21 and 24½ degrees of latitude, corresponds, in distance from the equator, with the district of greatest metallic wealth in Peru. The mean annual produce of the whole is 2,500,000 marcs of silver, about ten times more than what is furnished by all the mines of Europe; and 700 marcs of gold, about an equal quantity to what the European mines afford. Yet the ore is by no means remarkably rich; and the mean produce of the whole vein of Guanaxuato is four ounces of silver per quintal of minerals. The mining operations also are carried on at great expense, and not always in the most economical manner. In the mine of Valenciana, one of the richest in Guanaxuato, there is an administrator with a salary of 2500*l.* sterling; an overseer under him, with several under-overseers, and nine master miners, with 1800 workmen labouring in the interior of the mine. The expense of the powder alone has often amounted to 16,668*l.*, and of the steel for implements to 6250*l.* A new draught pit, 87 feet in circumference, and which was to reach to the enormous perpendicular depth of 1685 feet, was advanced, (when seen by M. Humboldt, in 1803,) to the depth of 603 feet, and was estimated to cost a million of piastres, and to require the labour of twelve years before it could be completed. The American miners have learned little from those of Europe since the 16th century, except the blowing with powder; and, though the court of Madrid has frequently attempted to introduce into the colonies the use of the more recent improvements in mechanical and chemical science, yet, as the mines are considered as the property of individuals, the government has no influence in directing the operations.

In the beginning of the 18th century, the quantity of gold and silver coined at Mexico, (which generally coincides with the quantity produced by the mines) was only from five to six millions annually; but the amount has been constantly on the increase for the space of 113 years, excepting the period from 1760 to 1767, so as to have been tripled in 50, and sextupled in 100 years. This enormous increase observable in late years, is attributed by M. Humboldt to a number of concurring causes, particularly to "the increase of population on the table land of Mexico, the progress of knowledge and national industry, the freedom of trade conceded to America in 1778, the facility of procuring at a cheaper rate the iron and steel necessary for the mines, the fall in the price of mercury, the discovery of the mines of Catorce and Valentiana, and the establishment of the Tribunal de Mineria." This progress of the mining operations is exhibited by the following Table of the gold and silver given into the mint of Mexico in periods of ten years.

Periods.				Value in piastres.
From	1690	to	1699	43,871,335
	1700		1709	51,731,034
	1710		1719	65,747,027
	1720		1729	84,153,223
	1730		1739	90,529,730
	1740		1749	111,855,040
	1750		1759	125,750,094
	1760		1769	112,828,860
	1770		1779	165,181,729
	1780		1789	93,504,554
	1790		1799	231,080,214
Total from	1690	to	1799	1,276.232 840

The other metals in New Spain have been greatly neglected, but are sufficiently worthy of attention; *copper* is found in a native state, and under the form of vitreous and oxidulated copper in several mines; and, from the quantity of instruments of that metal found among the ancient Mexicans, must be plentiful in the country. About 1565 quintals of plate copper, and 13,947 lbs. of wrought copper, amounting altogether to the value of 42,131 piastres, were exported from Mexico in 1802. *Tin* is found in veins, but is extracted chiefly from the earth of alluvial lands brought down the ravines; and about 58½ quintals were exported in 1803, to the value of 1,483 piastres. *Iron*, though little used by the ancient Mexicans, is more abundant than is generally believed, and particularly in the *provincias internas;* but is wrought with any degree of spirit only when a maritime war has interrupted the importation of steel and iron from Europe. *Lead* is very abundant in various parts of New Spain, but the mines are not wrought to any extent; and only 330 quintals were exported in 1802, besides what is required in the country. *Mercury* might be procured in considerable quantities from the numerous veins of Cinnebar which are found in Mexico; and, instead of being received, may one day be supplied by America; but at present 16,000 quintals are annually imported for the mining operations of New Spain. *Zinc*, *antimony*, and *arsenic* are found in several places, but *cobalt* has not been discovered among the minerals of the country; and *manganese* is less abundant than in the corresponding latitudes of the old continent.

Coal also is very rare, and is most abundant to the west of Sierra Verde near the lake of Timpanogos. *Rock salt* is found in the same place; and *soda* is merely disseminated in the argillaceous lands, which cover the ridge of the Cordilleras. The most abundant salt mine in Mexico is the lake of Penon Blaoco, in the intendancy of San Luis Potosi, the bottom of which is a bed of argil, yielding 12 or 13 per cent. of muriate of soda; but, as the Indians, who form the great part of the population, continue to season their food with pimento instead of salt, the consumption of these articles in Mexico is chiefly confined to the amalgamation of silver minerals, for which purpose from 20 to 30 fanegos are annually imported from Europe.

All the metallic wealth of New Spain, as well as in the other colonies, is in the hands of individuals; and the government is not even proprietor of the great levels. Individuals receive from the king a grant of a certain number of measures in the direction of a vein or bed; and are bound in return to pay very moderate duties on the minerals extracted from the mines, amounting in general to about 13 per cent. The number of persons employed in these subterraneous operations, throughout the whole of New Spain, does not exceed 30,000, which is only about $\frac{1}{200}$ of the whole population. The labour of a miner is entirely free; and no Indian or Mestizoe can be compelled to engage in the working of mines, or to continue in one place when he is thus employed. No miners are better paid than those of Mexico; and no where do they enjoy in greater security the fruit of their labours. Nor is their occupation observed to be more destructive of health than that of the other classes, although their exertions are great, and the temperature in which they exist very high. In several of the mines the heat is eleven degrees of Fahrenheit above the mean temperatures of Jamaica and Pondicherry; and the labourers, who carry the minerals on their backs, are exposed to a change of temperature, in ascending and descending, of more than

40 degrees. Yet, in these circumstances, they will remain for six hours under a load of 225 or 350 pounds, ascending eight or ten times successively stairs of 1800 steps. But this labour is accounted unhealthy, if they enter the mines above three days in the week. Those who blow the rock with powder, are found to suffer most in their health; and hence they seldom continue more than five or six years at this employment. They are well paid in every department of the work; and generally gain from 20 to 24 shillings per week, while labourers in the open air can earn only from six shillings and three-pence to seven shillings and sixpence in the same space of time. They are, nevertheless, much addicted to pilfering; and, though almost naked, contrive a number of plans to secrete the richer minerals, concealing them in their hair, their mouths, under their arm-pits, and sometimes even inserting them by means of cylinders of clay into their anus. They are of consequence regularly searched upon leaving the pit; and a register kept of the minerals detected about their persons, which, in one valuable mine, has been known to amount nearly to 3000*l.* per annum.

In this mountainous and extensive country, whose geometrical position and geological configuration contribute in producing the greatest diversity of climate, the variety of indigenous productions is immense; and scarcely a plant exists in the rest of the globe, which is not capable of being cultivated in some part of New Spain. Much has been done by distinguished botanists, employed by the government, to examine the vegetable riches of the country; but still many tracts remain to be explored, and new plants are daily discovered even in the central table-land, and in the very vicinity of the capital. The mines are by no means the principal sources of Mexican wealth; neither have they proved in general such obstructions, as has been imagined, to the progress of agriculture, which has been gradually ameliorating since the end of the 17th century. On the contrary, they have contributed powerfully, in many cases, to promote the cultivation of the soil. The subsistence required for the labourers and cattle employed in mining operations, has occasioned the establishment of farms in their neighbourhood, and brought under culture every spot of earth in the adjoining declivities and ravines. Nor do the natives easily forsake these settlements after the subterraneous operations have ceased, but continue rather to prefer these retired situations, and preserve a strong attachment to the residence of their forefathers.

The vegetable productions, which constitute the chief support of the Mexican people, form the great object of their agriculture. Among these the *banana* is one of the most important, corresponding in utility with the grain of Europe, and the rice of Asia; and scarcely any other plant is capable of producing so great a mass of nutritive substance on the same space of ground. The fruit is ready for being gathered in the tenth or eleventh month after the suckers are planted; and the plantation is perpetuated by fresh shoots, without any other trouble than merely cutting the stalks on which the fruit is ripe, and digging slightly around the roots once or twice a-year. A spot of 1076 square feet, containing from 30 to 40 plants, yields about 4414 pounds avoirdupoise of nutritive food, while the same space in wheat is calculated to yield only 30 lbs. and in potatoes not more than 90 lbs.; so that the produce of bananas is to the former as 133 to 1, and to the latter as 44 to 1. In fertile regions, a legal arpent, (about 54,998 square feet,) planted with the large banana, will maintain 50 individuals; while the same extent sown with wheat would furnish subsistence only to two persons. The fruit is prepared in a variety of ways; being dressed like the potatoe, or dried and pounded into flour, or preserved like figs, by exposure to the sun, when it acquires the aspect and odour of smoked ham. In the same region with the banana is cultivated the *juca*, which yields the flour of manioc, the bread of which is known under the name of cassave. This bread is very nutritive, perhaps on account of the sugar which it contains; but, from a deficiency of gluten, it is very brittle, and inconvenient to be carried. The fecula of manioc, however, when grated, dried, and smoked, is unalterable, and is neither attacked by insects nor worms. Even the juice of the bitter root, which, in its natural state, is an active poison, may be converted, by boiling and skimming, into a nutritive brownish soup. The cultivation of the manioc requires more care than that of the banana, resembling rather that of the potatoe, and yielding its crop about seven or eight months after the plantation of the slips. *Maize*, an indigenous American grain, occupies the same region with the two last mentioned, and is of still greater importance than either. Excepting a species of rye and of barley, maize is supposed to have been the only kind of grain known to the Americans before the arrival of the Spaniards, and is capable of being cultivated over a much greater extent of latitude than the cerealia of the old continent. Its fecundity in Mexico is above any thing that Europeans can imagine. When favoured by heat and humidity, the plant acquires a height of from $6\frac{1}{2}$ to $9\frac{1}{2}$ feet, and yields at an average in the equinoxial region of New Spain. 150 grains for one. In fertile lands, one fanega of maize produces from 300 to 400, and, in the beautiful plains between San Juan del Rio and Queretaro, sometimes even 800; but, under the temperate zone, it produces in general only from 70 to 80 for 1, though, sometimes, from 180 to 200.

The maize is the principal food of the Mexicans, and its price modifies that of all other provisions. There is no grain more unequal in its produce, according to the changes of moisture or of temperature, varying in the same field in different years from 40 to 300 for 1; and when the harvest is poor, either from want of rain or from premature frost, the greatest distress is experienced. Its mean price is 5 livres in the interior; but as there are no magazines in the country, to make the superabundance of one year supply the deficiency of another, it has been known to fall as low as $2\frac{1}{2}$ livres, and to rise as high as 25 The natives, in these cases, feed on unripe fruit, berries, and roots, which occasion many diseases and great mortality among the children. Some kinds of maize ripen in six weeks or two months; so that in warm and moist districts, two or three crops are raised in the year. This grain is eaten boiled or roasted, and its meal employed in gruels, or made into bread. By partly malting and infusing the grain of maize, the Indians prepare a great variety of spiritous, acid, and sugary drinks, generally known by the name of *chicka*, some of which resemble beer, and others cider. The juice pressed from the stalk, which contains a considerable quantity of saccharine matter in the tropical region, yields a rough sugar, or may be fermented into a spiritous liquor, called pulque de mahis, which is an important object of commerce in the valley of Toluca. This grain will keep, in the temperate climates, for three years; and, where the mean temperature is below 57° of Fahrenheit, for five or six, provided the crop is not cut too early. The whole of New Spain is calculated to produce at an average 17 millions of fanegas of maize, or 1765½ millions of lbs. avoirdupoise; and, in good years there is more reaped than the country can consume; but, as it almost never succeeds in the warmer and in the colder regions, much of the interior commerce consists in the conveyance of this grain, great quantities of which also are sent to the Spanish islands in the West Indies.

The cerealia of Europe, viz. wheat, spelt, barley, oats, and rye, are no where cultivated in the equinoxial part of Mexico, unless in elevations of 2600 or 2900 feet; and on the declivity of the Cordilleras. between Vera Cruz and Acapulco, these grains are not sown under an elevation of 3900 or 4200 feet; but it appears that wheat will ripen in much smaller elevations, even of 1600 or 1900, under latitude 10°. These grains, in most parts of New Spain, suffer chiefly from the deficiency of rain, and much use is made of irrigation in their culture. The *wheat* is watered when the young plants begin to spring up in January, and again in the beginning of March, when the ear is becoming visible; sometimes the whole field is inundated before sowing. In the more fertile parts of the table land, such as between Queretaro and the town of Leon, the wheat returns 40, and even 50 or 60 for 1; and the mean produce over Mexico is from 25 to 30 for 1. The whole produce of wheat in New Spain is estimated at 331,000,000 lbs. avoirdupoise, and its mean price is from 17s. to 21s per carga, which weighs 331 lbs. avoirdupoise; but the high price of carriage frequently raises it to 37s. or 43s. The Mexican wheat is of the best quality, large, white, and nutritive; but is with difficulty preserved more than two or three years. *Rye* and *barley* are cultivated in the highest regions; and the latter yields abundant crops in places where the thermometer is seldom above 57° of Fahrenheit. *Oats* are little cultivated, and seldom seen in the country. The *potatoe* appears to have been introduced into Mexico along with the European grains, and to have been brought from Peru or New Grenada. It is cultivated in the highest and coldest regions of the Cordilleras, and grows in some places to the size of nearly one foot in diameter, while the quality is excellent. It is preserved by the natives for whole years by exposing it to the frost, and drying it in the sun. Other nutritive roots are, the *oca*, which grows only in the cold and temperate regions; the *iguame*, a root which, in a fertile soil and warm climate, grows to so enormous a size as to weigh not less than 55 or 60 lbs.; and the *batate*, which also requires a warm country. Among the useful plants of Mexico may also be mentioned the *cacomite*, a species of tigridia, the root of which yields a nutritive flour; the *love-apple*; the *earth-pistachio*; and the different kinds of *pimento*, the fruit of which is as indispensable to the natives as salt to the whites.

The Mexicans possess all the fruit trees and garden stuffs of Europe; but it is not easy to ascertain which of these existed among them before the arrival of the Spaniards. It is certain that they were always acquainted with onions, haricots, gourds, and several varieties of cicer; and Cortez expressly mentions onions, leeks, garlic, cresses, borrage, sorrel, and artichokes; but no species of cabbage or turnip appears to have been cultivated among them. The central table land produces in the greatest abundance, cherries, prunes, peaches, apricots, figs, grapes, melons, apples and pears. The ecclesiastics, and particularly the missionaries, contribute greatly to spread the European fruits and vegetables from one end of the American continent to the other. Even the orange and citron trees are now cultivated throughout all New Spain, nay on the central table land, and there can be little doubt that the olive and mulberry, with hemp and flax, would equally flourish in New Spain, were not their cultivation discouraged by the jealousy of the mother country. Besides extracting liquors from the maize, manioc, banana, and the pulp of different kinds of mimosa, the Mexicans cultivate a species of *agave*, called maguey de pulque, for the express purpose of preparing a spiritous liquor from its juice, which is carefully collected by cutting the central leaves at the period of efflorescence, and of which one plant, about five feet in height, will yield, in the course of five months, a quantity equal to 67 130 cubic inches. Even in an ordinary soil, 150 bottles may be procured from one maguey in the season, and the value of each day's juice is estimated at 10 or 12 sols. The plant multiplies with great facility, and resists the cold of the higher regions; and its cultivation is found to be a sure mode of gain. The juice has a very agreeable sour taste, and so very easily ferments, that in three or four days a viscous beverage resembling cider is procured. It has a fetid odour like putrid meat; but, after custom has surmounted this obstacle to its use, it is generally preferred by Europeans to every other liquor, and is accounted stomachic, strengthening, and nutritive.—There are plantations in the north of Toluca, where the best is produced, which annually bring in more than 1600*l.* sterling; and this cultivation is so profitable to the revenue, that, in 1793, the duties which it paid in the three cities of Mexico, Puebla, and Toluca, amounted to the sum of 178,880*l* sterling. A very intoxicating brandy is procured from a different species of the same plant, which is prohibited by the government as prejudicial to the Spanish brandy trade, but which is manufactured in an illicit manner to a great extent. The leaves of this agaue are also manufactured into thread and paper; and its prickles were formerly employed as pins or nails by the Indians; so that, next to the maize or potatoe, it may be considered as the most useful production in the mountainous districts of equinoxial America. The *vine* is little cultivated, in consequence of government restrictions; but might be raised with great success in all the mountainous and temperate regions.

The cultivation of those productions which supply the raw materials of commerce and manufactures has recently increased in Mexico to a considerable extent. The profit of raising *cotton* is more than double that of grain, and that of *sugar* more than four times; but it is only in the warmer districts that these crops can be cultivated. In these districts there are already plantations cultivated by free Indians, which yield annually about a million and a half pounds of sugar; and in process of time the continent of America is likely to supplant the West India Islands in the cultivation of sugar, coffee, and cotton.

Cotton was one of the ancient objects of cultivation in Mexico, and some of the finest quality is raised on the western coast; but as the inhabitants of these places are still unacquainted with the use of machines for separating the cotton from the seed, the price of carriage is a great obstacle to this branch of Mexican agriculture. *Flax* and *hemp* may be advantageously cultivated, wherever the climate does not admit the growth of cotton; but their culture has hitherto been discouraged. *Coffee* is little used in Mexico; and is only beginning to be cultivated in the country. The *cocoa tree* was generally cultivated before the arrival of the Spaniards, by whom it was conveyed to the Canaries or Philippines, but is now almost totally neglected. Its seeds were formerly used as money, and in some places are still applied to that purpose by the common people, at the rate of six grains for one sol. *Vanilla*, though bearing a high price in Europe, is little cultivated in Mexico, except in the intendancies of Vera Cruz and Oaxaca. It thrives wherever there is heat, shade, and moisture, and is planted so as to climb along the trunks of trees. It principally abounds on the eastern slope of the Cordillera of Anahuac, between the 19° or 20° of latitude, and in the same latitude is procured the *sarsaparilla* and *jalap* (or purga de Xalapa,) of which last between two and three thousand quintals are annually exported from Vera Cruz. *Tobacco*, anciently used by the Mexicans both in smoking and snuff, might become an important branch of agriculture, if the trade were free; but it is entirely prohibited, except in a few licensed spots, or rather is grown only by the government. *Indigo* is very little cultivated in Mexico; and the plantations along the western coast do not raise what is sufficient for the few manufactures of home cotton cloth. The article is annually imported from Guatimala, where it is raised in considerable quantities.

The domestic animals of Mexico were very few before the conquest. The Mexicans were not acquainted with the Llama, which was confined to the southern hemisphere; and they made no use of the wild sheep of California, or the goats on the mountains of Monterey, or the wild oxen in the vicinity of Rio del Norte. Dogs were used in some of the northern tracts in the carriage of tents, as in Siberia; and the flesh of a mute species of these animals, named the Techichi, was employed as food. A numerous class of the inhabitants named Flamama, were compelled to labour as beasts of burden, and to pass their lives on the highway under loads from 66 to 88 lbs. weight. But, since the middle of the 16th century, all the most useful animals of the old Continent, oxen, horses, sheep, and hogs, have multiplied surprisingly in all parts of New Spain, and especially in the vast plains of the Provincias Internas: nor have they at all degenerated in the New Continent, according to the fanciful hypothesis and rash assertions of *Buffon*. Numerous herds of *horned cattle* feed in the finest pastures along the eastern coast, particularly at the mouths of the rivers Alvarado, Guasacualco, and Panuco. The natives make little use of milk, butter, or cheese, and it is only among the mixed casts that the latter is in request. The *horses* of the northern provinces, and particularly of New Mexico, are not less celebrated than those of Chili. These animals wander wild in the savannahs of the Provincias Internas, and numbers are exported to Natchez and New Orleans. Many Mexican families are said to possess from thirty to forty thousand head of horses and oxen. *Mules* are still more numerous. More than 5000 are employed as an object of luxury, or in the carriages of the city of Mexico; and the commerce of Vera Cruz alone occupies annually about 70,000 of these animals, multitudes of which perish on the highways from the excessive fatigues of their journeys. The rearing of *sheep* has been strangely neglected, although they might easily be made to change their climate with the seasons, without at all interfering with the agriculture of the country. It is remarkable that neither the common *hog*, nor the *poultry*, which are found in all the islands of the South Sea, were known to the ancient Mexicans. The former have been introduced both from Europe and the Philippines, and have multiplied amazingly on the central table land. Before the arrival of the Spaniards, some of the more civilized tribes reared a few turkeys, pheasants, ducks, and moor hens about their houses; but now the different varieties of hens, particularly those of Mosambique, of which the flesh is black, have become common wherever colonies have settled. The *goose* is the only species of European poultry which is no where to be found in Spanish America.

The rearing of *silk-worms* was introduced by Cortez soon after the taking of Mexico; and considerable quantities of silk were produced in different provinces. But the injudicious restrictions imposed by the government on the native manufactures, and the interest which the Philippine company had in the sale of Asiatic silks to the Mexicans, have almost annihilated this branch of colonial industry. There are several indigenous caterpillars in New Spain, from which an inferior silk, called *Misteca*, is procured, which was an object of commerce even in the time of Montezuma, and of which handkerchiefs are still manufactured in the intendancy of Oaxaca. *Bees* are an object of attention in New Spain, chiefly for the sake of their wax, of which so great a quantity is consumed in the Catholic worship. One species, peculiar to the New Continent, has no sting, or at least so feeble a weapon as to produce no sensible injury; and from this circumstance they are known in the Spanish colonies by the name of Angelitos, *little angels*. The *Cochineal* insect has been reared in New Spain from the most remote period; but, in consequence of the vexations to which the natives were exposed in the beginning of the conquest, this branch of Indian industry became almost entirely neglected, except in the intendancy of Oaxaca. In the rainy seasons, the Indians make their cochineal insects travel to drier regions, by carrying them in baskets covered with palm-leaves.

The principal fisheries on the coasts of New Spain, are the whale and pearl fisheries. The western coast of Mexico, especially that part of the great ocean situated between the gulf of Bayonna, the three Mary Islands, and Cape St. Lucas, abounds in *spermaceti whales*, or cachalots. Till 1788, the whale fishers frequented the coast of Chili and Peru; and seldom above a dozen of these vessels doubled Cape Horn annually. But, since the voyage of Colnet to the Gallipagos made known the abundance of cachalots in the great ocean to the north of the equator, more than 60 vessels have been seen there under the English flag alone. One of the large cachalots will yield 125 barrels of spermaceti, eight of which forming a tun, used to sell in London from 80*l.* to 100*l.* sterling; yet the Spanish Mexicans make no attempt to share in this profitable pursuit. One cause of this neglect may be, that tapers of bees-wax only are permitted to be used in the churches, and spermaceti therefore is not in much request in New Spain; but it is also certain, that the sloth of the colonists prevents them from engaging in so laborious an employment. *Pearls* are procured in greatest abundance between the islands of Cubagua and Coche, and the coast of Cumana, at the mouth of the Rio de la Hacha, in the gulf of Panama, and on the eastern coast of California.

The ancient Mexicans were acquainted with the process of weaving cotton; and, soon after the conquest, the manufacture of cloth from the wool of European sheep was introduced into the country. But the Spanish government, though never actually prohibiting the establishment of manufactures in their colonies, have always discouraged those which were supposed to interfere with the demands for the same articles from the mother country. Notwithstanding all obstacles, however, many settlers from Spain have carried to the new continent the industry of their native provinces. The manufacture of coarse stuffs can easily be carried on at a low rate, where the raw materials are found in abundance; and the prohibition of commerce with neutrals, during the late hostilities throughout Europe, favoured greatly the making of *calicoes*, *fine cloths*, and other articles of luxury. The oldest *cloth* manufactures are those of Tezcuco, established in 1592, which, by degrees, passed entirely into the hands of the Indians and Mestizoes of Queretaro and Puebla. In these establishments there is great imperfection in many of the technical processes, particularly in that of dyeing. The workmen are treated in a great measure like slaves, being shut up all the week as in a prison, and flogged unmercifully for the smallest trespass. Though free, they are subjected to this constraint, by being kept continually in debt to their employers, who take care to furnish them with opportunities of spending their gains in drunkenness, and thus acquire a right to confine them at work, as the necessary step for procuring payment. Little *silk* is now manufactured in New Spain, and only a few stuffs of *cotton*, mixed with silk. Neither are there any manufactories of flax, or hemp, or paper. The manufacture of *tobacco*, which is a royal right, is very considerable; and in one great manufactory of segars at Queretaro, 3000 people are employed. The manufacture of hard *soap* is a considerable article of commerce at Puebla, Mexico, and Guadalaxara, and is greatly facilitated by the quantities of soda found in most parts of the table land of New Spain. The town of Puebla was formerly much celebrated for its manufactories of *delf-ware* and *hats*; but the former article has been much neglected of late years, in consequence of the low price of the stone-ware imported from Europe. The manufacture of *powder* is a royal monopoly; but immense quantities, (nearly three-fourths of the whole that is consumed in the country,) are made and sold in a contraband manner. One of the most extensive of the Mexican manufactures is that of *plate*; and, in the smallest towns there are gold and silversmiths, in whose shops workmen of all casts are employed. The academy of fine arts in the capital has diffused a taste for beautiful antique forms; and services of plate to the value of 200,000 francs have been manufactured in that city, which might rival in point of elegance and workmanship, the finest in Europe. The *coining of money* in the mint of Mexico is little else than a manufacturing establishment. It was established in 1535, and was first carried on by contract with individuals; but, since 1733, is entirely placed under the officers of government. Between 350 and 400 workmen are employed in this business; and so great is the number of machines, that, without any extraordinary exertion, they are able to coin annually thirty millions of piastres. It is computed by M. Humboldt, that all the silver produced in all the mines of Europe together every year, would not suffice to employ this extensive work above fifteen days; and that from this mint, since its establishment, has issued coin to the value of 408,000,000*l.* sterling. The produce of the manufacturing industry of New Spain is computed by the same author at 7 or 8 millions of piastres, (1,470,000*l.*, or 1,680,000*l.* sterling,) per annum.

The interior and coasting trade of Mexico is greatly impeded by the want of navigable rivers and artificial canals. The Rio de Santiago, which traverses the most populous part of the country, through a course of 170 leagues, might be rendered navigable at a moderate expense; and canals might be opened through the valley of Mexico; but the great lines of communication between the capital and the principal sea ports can never be improved by natural or artificial navigations. The town of Mexico forms the central point of the interior commerce; and the whole surrounding table land may be travelled by wheel-carriages in all directions; but, from the bad state of the roads, beasts of burden are preferred. The communication with the coasts is still more difficult; but means are said to be recently employed for facilitating the conveyance of goods both from Acapulco and Vera Cruz. The objects of this interior commerce are the exchange of goods between the different provinces, particularly between Mexico and the *provincias internas*; several productions from South America, conveyed through the country for exportation; and the articles which are exported or imported at the two great ports of Acapulco and Vera Cruz. As the inland provinces enjoy, in a great measure, the same climate, and consequently possess the same productions, it is chiefly the consumption of commodities by the mines which creates the interior commerce; but, as the crops of maize are seldom equally productive over so vast an extent of country, the conveyance of this necessary article from one place to another constitutes a considerable traffic. Thousands of mules, from Chihuahua and Durango, arrive every week at Mexico with bars of silver, hides, tallow, flour, and some wine, and take back, in return, woollen cloth of native manufacture, iron, steel, mercury, and goods from Europe and the Philippines. In time of war, when the navigation round Cape Horn becomes more hazardous, much of the cocoa of Guayaquil, the copper of Guasco, and the indigo of Guatimala, pass through the isthmus of Mexico to be shipped at Vera Cruz.

The foreign commerce of Mexico is naturally divided into that of the South Sea, and that of the Atlantic Ocean. The latter experiences great disadvantages from the want of commodious sea-ports; and almost all its operations have for centuries been concentrated at Vera Cruz, which is rather a bad anchorage than an actual harbour. The eastern coast, besides its sand banks, at all times is subject to violent hurricanes during the winter half of the year, and to the formidable yellow fever during the summer season. On the western coast are two magnificent ports, San Blas and Acapulco, the last of which is counted one of the most admirable basins in the world. But tremendous hurricanes blow on this coast during the months of July and August; and, even in September and October, the two fine harbours now mentioned are difficult of access. The principal articles of exportation at Vera Cruz, (exclusive of cocoa from Guyaquil, and indigo from Guatimala,) at an average of several years, are—

Gold and silver in ingots, coin and wrought plate, to the value of	£3,570,000
Cochineal	504,000
Sugar	273,000
Flour	63,000
Mexican indigo	43,680
Salted provisions, and other eatables	20,000
Tanned hides	16,800
Sarsaparilla	18,900
Vanilla	12,600
Jalap	12,600
Soap	10,500
Campeachy wood	8,400
Pimento of Tabasco	6,900

The articles of importation are—

Linen, cotton, woollen cloth and silks, to the value of .	£2,310,000
Paper	210,000
Brandy	210,000
Cocoa	210,000
Mercury	136,500
Iron	126,000
Steel	42,000
Wine	147,000
Wax	63,000
The average value of the whole exportation	4,620,000
Ditto, importation	3,150,000
Commercial circulation .	£7,770,000

The commerce of the western coast is confined to the Manilla galleon; the coasting trade with Guatimala and San Blas; and a few vessels annually dispatched to Guyaquil and Lima. The oldest and most important branch of the trade of Acapulco, is the exchange of the precious metals of Mexico for the merchandize of China and the East Indies. A single galleon, from twelve to fifteen hundred tons, sails from Manilla about the end of July with the south-west monsoon, bringing a cargo of muslins, printed calicoes, coarse cotton shirts, raw silks, and China silk stockings, jewelleries from Canton or Manilla, spices, and aromatics; and generally accomplishing the voyage in three or four months. The value of the cargo is limitted by law to half a million of piastres, (105.000*l.* sterling) but generally amounts to three or four times that sum. Of this lucrative merchandize the merchants of Lima have the greatest, and the ecclesiastical corporations the next highest share; and it is generally purchased with so much avidity, chiefly by a few great houses in the capital, that sometimes the whole sales are completed before the arrival of the galleon has been known at Vera Cruz. The return cargo consists of bars of iron, a little cochineal, cocoa, wine, oil, Spanish wool, and principally of the precious metals, to the value of a million of piastres. A number of passengers, particularly monks sent from Spain and Mexico to the Philippines, generally go with the galleon to Manilla, which sails in February or March, and by means of the trade winds accomplishes its long voyage in 50 or 60 days. A vessel is also dispatched annually from Manilla to Lima, one of the longest and most difficult of all voyages, as the ship must first discover the Mexican coast, and then steer southwards. The trade of Acapulco with the ports of Guayaquil and Lima is far from being active; and consists chiefly in the importation of copper, oil, Chili wine, a small quantity of sugar and quinquina (bark) from Peru, and cocoa from Guayaquil, sending thither in return a few woollens, a little cochineal, and contraband goods from the East Indies. The length and difficulty of the navigation from Acapulco to Lima, are the great obstacles to this trade between Mexico and Peru. The passage is peculiarly difficult from north to south; and often more time is required to sail the 210 marine leagues from Guayaquil to Callao, than to pass from Acapulco to Manilla through a course of 2,800 leagues. The chief hazards and delays arise from dead calms, violent hurricanes, and strong currents among the Gallipago islands. Notwithstanding the excellence of the ports on the west coast of Mexico, the coasting trade is extremely languid; and neither the spermaceti whale-fishery, nor the beaver fur-trade from Nootka, has been able to arouse the Spanish energies. The customs are not uniform in the different ports of the Spanish colonies, and are distinguished into royal and municipal duties. *Free effects*, *i. e.* the produce of Spanish agriculture and manufactures, pay, on landing, 9½ per cent.; *contributable effects*, *i. e.* the foreign produce manufactured in Spain, pay 12½ per cent.; *foreign effects* pay 7 per cent. having previously paid 15 per cent. upon entering, and 7 upon leaving the ports of the mother-country.

The contraband trade of New Spain is very extensive, and is carried on principally by the ports of Campeachy and Vera Cruz. In time of war, when the communication with Spain is interrupted, and the government obliged to admit occasional commerce with neutrals, this trade is pursued with great facility, and often amounts to one-third of the whole regular commerce in time of peace.

Previous to the year 1778, the whole commerce of Spanish America was monopolized by the cities of Cadiz and Seville; but, at this period, fourteen other ports were opened to the productions of the colonies; and this arrangement has been attended by a regular increase of the public revenue. The state of commerce in New Spain has again been greatly changed since the year 1794; and the foreign goods required in that country are those of the greatest value, the finest cloths, muslins, silks, wines, and other liquors. The produce of its own mines has also considerably increased during the same period; and more specie is ready to pay for these higher priced commodities. About the commencement of the nineteenth century, the importation into Mexico, including the contraband trade of both coasts, amounted to 20 millions of piastres; and the exportations of its agriculture and manufacturing produce to 6 millions; but the mines produce annually 23 millions, of which 8 or 9 millions are exported on account of the king, leaving 15 millions to liquidate the excess of the import over the export trade; from which will remain about one million for the increase of specie in the country. "But, by allowing a free course to the national industry," says M. Humboldt, "by encouraging agriculture and manufactures, the importation will diminish of itself, and it will then be easy for the

Mexicans to pay the value of foreign commodities with the productions of their own soil. The free cultivation of the vine and the olive on the table land of New-Spain; the free-distillation of spirits from sugar, rice, and the grape; the exportation of flour, favoured by the making of new roads; the increase of plantations of sugar-cane, cotton, and tobacco; the working of the iron and mercury mines; and the manufacture of steel, will perhaps one day become more inexhaustible sources of wealth, than all the veins of gold and silver united. Under more favourable external circumstances, the balance of trade may be favourable to New Spain, without paying the account which has been opened for centuries between the two continents entirely with Mexican piastres."

The revenue of New Spain, which has increased in an extraordinary degree in the course of the 18th century, was estimated, about the beginning of the 19th century, at twenty millions of piastres, or 4,200,000*l.* sterling. Of this sum, five millions and a half arise from the produce of the gold and silver mines; four millions from the government monopoly of tobacco; three millions from the alcaoalas or customs; one million and a half from the Indian capitation tax; and the remainder, from the duty on the fermented liquor pulque, from the duty on imports and exports, from the sale of Papal indulgences, from the post-office profits, from the sale of gunpowder, from clerical benefices, from the sale of cards, from stamp duties, from the farming of cock-fighting, from duty on the sale of snow, &c. About one half of the whole revenue is consumed by the expenses of the administration; and of the other half, about one-third is remitted to other Spanish colonies; and two-thirds to the mother country.

Nearly one-fourth of the whole revenue is expended on the military defence of the country, in which about 30,000 troops are employed. Of these, only 10,000 are regulars: of which, about 4,000 cavalry, stationed in the presidios, or military posts, to check the incursions of the Indians, are remarkably active and hardy soldiers, and incessantly exposed to severe service. The greater part of the military establishment is composed of provincial militia, raised more for shew than use; and chiefly originating in the love of military titles and rank, among a few Spanish families and wealthy creoles. The situation and physical aspect of the country, render it easily defensible against the attack of an external enemy.

The accounts of the population of Mexico, at the period of its subjugation to the Spaniards, are founded on very vague conjectures, and have been, in some cases, obviously exaggerated. Around the capital of Mexico, and probably in the whole kingdom of Montezuma, (which, however, did not equal in surface the eighth part of the present kingdom of New Spain,) there is good reason to conclude, from the extensive ruins of towns and villages, that the population was formerly much greater than at present; but this great body of people were concentrated within a very small space; and it is now well ascertained, that the whole of the vast region, denominated New Spain, is much better inhabited than it was before the arrival of the Europeans. The augmentation of tithes, of the Indian capitation tax, and of all the duties on consumption; the progress of agriculture and civilization, and the appearance of the country covered with newly constructed houses, all give evidence of a rapid increase in every part of the kingdom. In those districts where the climate is hot and humid, there is so great mortality, chiefly among the children and young people, by tertian fevers, (which is greatly aggravated by the practice among the native tribes of abandoning the infected,) that the population makes no sensible progress; but, in the colder regions, which compose the greatest part of the kingdom, the proportion of births to deaths is as 190, or even as 200, to 100; and the average over the whole country as 170 to 100. From a variety of *data*, Humboldt estimates the whole population in Mexico, in 1808, at more than 6,500,000. The most destructive checks to the population are the *small-pox*, which used to produce dreadful ravages among the Indians, whose constitution seems to be ill adapted for cutaneous diseases; a kind of plague called *marlazahuatl*, which appears at intervals of 100 years, and spreads its ravages over the coldest and driest regions, but never affects the white inhabitants or their descendants; *scarcity of provisions*, sometimes approaching to famine, when any great drought or local cause has damaged the crop of maize or potatoes, and which is always attended by epidemical diseases; and formerly the *compulsory labours* in the mines. But by the introduction of the cow-pox, the progress of agriculture, and the abolition of the *mita*, or compulsion of miners, these checks are greatly abated, and the general population greatly on the increase. The addition made to the number of inhabitants in New Spain, by the arrival of new colonists from Europe, does not exceed, says M. Humboldt, 800 individuals annually.

The Mexican population, like that of the other Spanish colonies, consists of four great casts, viz. the Whites, the Indians, the Negroes, and the people of mixed extraction. But the first class is subdivided into two races, viz. the individuals born in Europe; and the Spanish Creoles, or whites of European extraction, born in America. The last is subdivided into three races, viz. the Mestizos, or descendants of whites and Indians; the Mulattoes, or descendants of whites and negroes; and the Zembos, or descendants of negroes and Indians. The Indians, or indigenous Americans, excluding those who have any mixture of European or African blood, have considerably increased during the last fifty years; and constitute, in general, about two-fifths of the whole population in New Spain. In some districts, as in the four intendancies of Guanaxuato, Valladolid, Oaxaca, and La Puebla, they amount even to three-fifths. This race are rarely to be found in the north of Mexico, and hardly ever met with in the provincias internas. Among these there must originally have been many different tribes; as, besides an immense number of dialects, there are twenty distinct languages still spoken among them; fourteen of which have been reduced to grammars and dictionaries, viz. the Mexican, or Aztec, the Otomite, the Tarasc, the Zapotec, the Mistec, the Maye or Yucatan, the Totonac, the Popolouc, the Matlazing, the Huastec, the Mixed, the Caquiquel, the Taraumar, the Tepehuan, and the Cora. Of these, the first is most widely diffused, extending through a line of 400 leagues, from the 37° of north latitude to the Lake of Nicaragua; and the second is next in point of extent. These Indians in general bear a resemblance to those who inhabit Canada, Florida, Peru, and Brazil, in their swarthy copper colour, flat smooth glossy hair, small beard, long eye, with the corner directed upwards towards the temples; prominent cheek-bones, thick lips, a squat body, an expression of gentleness in the mouth, contrasted with a gloomy and severe look. The Indians of New Spain have even a more swarthy complexion than the inhabitants of the warmest climates of South America, even though the former are clothed, while the latter are quite naked. The Mexicans, particularly those of the Aztec and Otomite races, have also more beard than the Indians of South America; and this would seem to be generally the case in proportion as they are removed from the equator. They are remarkably free from every kind of deformity, (which some writers ascribe to the great simplicity in which their ancestors had lived for so long a period;) and in those districts where the goitre or tumour in the thyroid gland prevails, the Indians, and generally their descendants the Mestizoes, are free from that affection. This freedom from natural deformities is more extraordinary among an agricultural race, than among the hunting and warlike tribes, in whose situation the feeble and deformed are more likely to perish, or to be exposed in their infancy, and may therefore be considered as more closely connected with their peculiar constitution and mode of life. They are likewise a long lived race, particularly those who are under European dominion; and would attain a still more advanced age, if they did not weaken their constitutions by intoxicating liquors. This is particularly the case with those who inhabit the valley of Mexico, and the environs of Puebla and Tlascala, where the agaue (of which the pulque or native wine is made,) is cultivated on a great scale; and likewise in the warm countries on the coast, where the sugar-cane is grown. The marks of old age, however, are rarely observed among them; as their heads never become grey, and their skin is little subject to wrinkles. It is not uncommon in Mexico, in the temperate zone of the Cordillera, to meet with natives, particularly women, who have reached 100 years of age, and who still retain their muscular strength entire. In the present degraded state of these native tribes, it is not possible to ascertain the genuine character of the race, which must unquestionably have suffered no small deterioration by the extinction of the higher ranks, the destruction of the ancient sources of knowledge, and the insulated and oppressed condition in which they are held. The Mexican Indian in his present state discovers no vivacity of manner or activity of mind, but is grave, melancholic, and silent, unless when he is under the influence of intoxicating liquors. Concealment of his motives and feelings, even in matters of indifference, is one of his leading characteristics; and as the progress of the passions is never discerned in his features, he appears (when he is excited) to pass from the utmost stillness of mind to the most violent commotion of spirit. The descendants of the ancient republicans of Tlascala still discover a considerable degree of energy and even of haughtiness in their character, and particularly among the pastoral tribes or Indios Bravos, (as the Spaniards call those who are not properly reduced under their dominion,) much more nobleness of mind and force of character are observable; but the agricultural Indian, or Mexican peasant, is patiently submissive under the vexations of the whites; and opposes them only by the resources of cunning, under the appearance of the most stupid apathy. In their intellectual character they appear as if altogether destitute of imagination; but after a little cultivation, discover great facility of apprehension, a talent for seizing the minutest distinctions, and a power of reasoning with remarkable coolness and method. In the imitative arts, and purely mechanical operations, they display a high degree of aptitude and acuteness; but have in general appeared to succeed in any of the fine arts, particularly in painting, more from application than from genius. Their amusements even partake of the same sedate and sombre character. Their music and dancing are terrific and melancholy; and, though the females would probably introduce a little more vivacity, yet, in the usual depressed state of savage and half civilized life, they are not permitted to join in these exhibitions, and are merely admitted to supply the male performers with liquor. In one particular, however, these Indians evince a refined and elegant taste, which would seem to betoken the remains of higher attainments, viz. in their universal love of flowers, and skilful arrangement of nosegays, herbs, and fruits. With regard to their political condition, they have derived few means of improvement from their European rulers. The great body of the people were indeed found by the Spaniards in a state of the utmost poverty, and subjection to their despotic princes and feudal chiefs; but their new masters, instead of alleviating, made haste to aggravate their oppressions; dragging them from their homes to work in the mines, or to carry the luggage of the armies, and appropriating to themselves, as a right of conquest, all that they possessed in lands or goods. Since the commencement, however, of the 18th century, their situation has become progressively better, and their interests have been taken under the protection of the intendants. A few of the great Indian families, or Caciques, who still remain, are entitled by the Spanish laws to share the privileges of the Castilian nobility; and they receive all the former homage which used to be paid to them by the inferior ranks. But their own privileges are more illusory than real; and, even where they have some authority as magistrates of the native villages, they are more oppressive than even the whites towards the tributary casts, and not at all superior to the lowest peasantry in point of knowledge or civilization. The Mexican Indians, when considered in a mass, present a picture of extreme misery; and scarcely any individuals are to be found among them who enjoy mediocrity of fortune. The greater part, banished into the more barren districts, and indolent from natural disposition, as well as discouraged by their political bondage, live in daily poverty; and even the few noble families who possess great plantations and vineyards, (to the value sometimes of 30,000*l.* or 40,000*l.*,) carefully conceal their wealth, generally going barefooted, and clothed in the same coarse garment with the lowest of their countrymen. The Indians are exempted from all direct imposts, but are subjected to a tribute or capitation tax, which has varied at different periods, and in different districts, but at present is usually eleven francs per annum. They pay also to the clergy ten francs for baptism, twenty for a certificate of marriage, twenty for interments, and from twenty-five to thirty in the form of voluntary offerings for masses, &c. They are deprived of the most important rights of citizens, by being counted as minors, under the tutory of the whites; so that every act which they sign, and every obligation which they incur beyond the value of fifteen francs, are declared null. They are kept in a state of complete insulation; prohibited from intermarriage with the whites; shut up in villages of their own; subjected to subaltern magistrates among themselves, who find their interest in perpetuating the ignorance and barbarism of the people; rendered incapable of commercial transactions; confined to the situation of common labourers or artisans; and thus completely excluded from all chance of advancing in civilization of manners, or acquisition of property. "Let the odious personal impost of the *tributo* be abolished," (says the enlightened Bishop of Mechoacan, in a memoir presented in 1799 to the Spanish monarch) "let the infamy which unjust laws have attempted to stamp on the people of colour be at an end;—let them be declared capable of filling every civil employment which does not require a special title of nobility;—let a portion of the demesnes of the crown, which are generally uncultivated, be granted to the Indians and the casts;—let an Agrarian law be passed for Mexico, similar to that of the Asturias and Gallicia, by which the poor cultivator is permitted to bring in, under certain conditions, the land which the great proprietors have left so many ages uncultivated, to the detriment of the national industry;—let full liberty be granted to the Indians, the casts, and the whites, to settle in villages, which at present belong only to one of these classes;—let salaries be appointed for all judges and all magistrates of districts;—these are the six principal points on which the felicity of the Mexican people depends."

The white inhabitants consist of whites born in Europe, called chapetones or gachupines, and those descended of Europeans in the Spanish colonies of America, or in the Asiatic islands, called Creoles. The laws allow the same rights to all whites; but the government, suspicious of the Creoles, has granted (or rather sold) public offices chiefly to the natives of Old Spain. Hence a perpetual hatred and jealousy exists between the Chapetones and Creoles; the meanest of the former counting themselves superior in blood, and having the chance of becoming superior in rank, to the most distinguished natives of the New Continent; and the latter, in contempt of this assumed pre-eminence, as well as in a spirit of alienation from a country which subjects them to such unworthy treatment, preferring the name of Americans to that of Spaniards. There are about 1,200,000 whites in New Spain, or a proportion of 16 to every 100 of the other casts; of whom not above 70,000 or 80,000 (a 70th part of the whole population, and only one to fourteen of the Creoles,) are natives of Europe. In all Spanish America, the word European is synonimous with Spaniard; and no Europeans, except such as are born in Old Spain, are admitted into the American colonies. The inhabitants of the more remote provinces, still conceiving the ancient power of Old Spain as predominant in Europe, regard the peninsula as the centre of civilization, and consider it as a mark of low extraction to be ignorant of the Spanish language. But in the capital of Mexico, the Creoles, being better acquainted with the present state of Europe, and instructed in French or English literature, fall into the contrary extreme; consider their own intellectual progress as superior to that of the peninsula; and prefer strangers from other countries before the Spaniards themselves. There is indeed considerable intellectual activity among the young Creoles, who apprehend the principles of science with great facility. At Mexico and Santa Fé the study of mathematics, chemistry, mineralogy, and botany, is very general, and the former city surpasses every other in the New Continent, not excepting those of the United States, in solid scientific establishments. The whites are also the exclusive possessors of great wealth, and nothing is more striking than the inequality of its distribution. There are many individuals, whose annual income, without any profit drawn from the mines, amounts to a million of francs, (41,670*l.* sterling;) and some of the great miners draw from that source alone an annual revenue of a million and a half of livres, (or 62,505*l.* sterling.) But the capitals of these monopolizers of money are by no means great in proportion, partly in consequence of the expensive mining operations in which they often engage, and the extravagant style in which they live.

There are fewer negroes in New Spain than in any of the European colonies under the torrid zone; and the whole kingdom is not supposed to contain above 6000 of that race, nor to receive above 100 annually of the 74,000 Africans who are exported every year to America and Asia. By the laws, there cannot properly be any Indian slaves in the Spanish colonies; but in Mexico, or in Peru, the Indios Bravos taken in the petty warfare, which is continually carried on along the frontiers of the provincias internas, are kept in dungeons, and treated as the most degraded bondmen. But all kinds of slaves are more under the protection of the law, and those laws are interpreted more in favour of liberty, in Mexico, than in any other European colony. A slave may compel his master to grant him liberty upon paying 1500 or 2000 livres, (62*l.* or 82*l.* sterling,) whatever may have been the amount of his original purchase money; or, if he can prove that he has been cruelly treated, he acquires his freedom by law, without any compensation to his proprietor.

The casts which spring from the mixture of these three races, amount nearly to 2,400,000. About seven-eighths of these are Mestizos, the descendants of a white and an Indian, and are distinguished by a pure white colour, a peculiar transparency of skin, small hands and feet, thin beard, and a certain obliquity of the eyes. They are of a milder character than the Mulattoes descended from whites and negresses, who are usually distinguished by the violence of their passions, and volubility of their speech. A Mestizo marrying a white man produces an offspring differing very little from the European race; but the children of a Mulatto and a white man are called quarterons, and the children of a quarteron female and Creole or European father, bear the name of quinterons. But a new alliance of this last mentioned cast with a white banishes all remains of colour. The descendants of negroes and Indian women are called Chinos or Zambos, though the latter denomination is usually confined to the children of a negro and mulatto, or a Chino female. All the casts of Indian or African blood preserve the odour peculiar to the perspirable matter of these races. The degree of whiteness of skin decides the rank which every one occupies in America; and a white who rides on horseback, though barefooted, accounts himself one of the nobility of the country. It thus becomes a very interesting point among them to estimate exactly the fractions of European blood which belongs to the different casts; and families, suspected of a mixed taint, frequently demand from the high court of justice a declaration of their whiteness. These declarations are said to be sometimes procured in cases not very obvious to the senses; but, when the colour of the skin is very repugnant to the judgment demanded, the sentence simply bears, "that such or such individuals may consider themselves as whites."

The inhabitants of New Spain have more science than literature. Mathematics are carefully taught in the university of Mexico, but still more so in the school of mines in that city; and New Spain can boast of having given birth to a celebrated self-taught geometrician, Don Joacquin Velasquez, who was born in 1732, and who rendered the most essential services to his country. Astronomy has long been a favourite subject of study in this country, and was successfully cultivated about the end of the eighteenth century by Velasquez abovementioned, and by Gama and Alzate. The last of these, a man of ardent genius, had great merit in exciting his countrymen to the study of the physical sciences; and, for a long time, encouraged a studious spirit among the Mexican youth, by the publication of his *Gazetta de Litteratura.* Gama, the friend and fellow-labourer of Velasquez, became, under great disadvantages, a well-informed astronomer, and published several excellent memoirs on eclipses, on Mexican chronology, and on the climate of New Spain. The principles of chemistry, which is known in the colonies by the name of new philosophy, are very generally understood among the Mexicans. In the botanical garden of Mexico, annual courses of lectures are delivered on botany; and several natives of New Spain, particularly M. Sesse and M. Echeveria, have distinguished themselves by their acquirements in this science. In the academy of the fine arts at Mexico, there is a more complete collection of casts than is to be found in any part of Germany; and, in this institution, instruction is communicated gratis to the youth of all descriptions, of whom several hundreds are assembled every evening, in large and well-lighted apartments, busily employed in drawing from the most elegant models. The good effects of this establishment are very visible in the architecture of the country, particularly in the symmetry of the buildings, the hewing of the stone, and the ornaments of the capitals and stucco relievos. There are edifices, not only in the capital, but also in the provincial towns, which would appear to advantage in the finest streets of Europe, and which are constructed at an expense often of a million or a million and a half of francs, or 41,670*l.* and 62,505*l.* sterling. An equestrian statue of King Charles IV. cast by M. Tolsa, professor of sculpture at Mexico, is considered as next in merit, of any similar work extant, to that of M. Aurelius at Rome.

The clergy in Mexico amount to the number of 10,000 individuals, of whom one-half are regulars, who wear the cowl; and, including lay-brothers and sisters, or servants, may be rated at 13,000 or 14,000. This number is much inferior to what has been generally supposed, and, in proportion to the population, is not the tenth-part of those in Old Spain, or in France before the Revolution. The ecclesiastical establishment in Mexico resembles that of Spain, with its full train of dignitaries. The inferior clergy are divided into three classes: namely, curas, who are parish-priests in those parts of the country where the Spaniards have settled; doctrineros, who have the charge of districts inhabitated by the Indians subject to the Spanish government; and missioneros, who are employed in teaching and converting the fiercer tribes, who resist the Spanish yoke, and live in the more remote regions. A great many of them suffer extreme poverty, while the revenues of some surpass those of many sovereign princes in Germany. The archbishop of Mexico possesses an income of 650,000 francs, or 27,085*l.* sterling, and several of the bishops not much less; while there are clergymen of Indian villages whose yearly income does not exceed 500 or 600 francs, from 20*l.* to 25*l.* sterling. Cortez complained, even in his time, of the extravagant luxury and scandalous lives of the canons; and requested that religeux, or regular monks, might be sent out in preference; but the advice was not followed.

Their labours among the natives have tended rather to change their ceremonies than their sentiments; and it has been the policy of the teachers, from the beginning, to tolerate, and even to reconcile with Christianity, as much as possible of the ancient system. The sanguinary spirit of the old rites is, indeed, abolished: but, otherwise, the Indians know little more of religion than the exterior forms of worship, in which, according to the Catholic ritual, they find one of their principal sources of amusement. The festivals of that church, the fireworks with which they are accompanied, the processions, dances, and fantastical dresses which are exhibited, interest the lower Indians in the highest degree and afford an opportunity for displaying all the peculiarities of the national character.

New Spain was formerly distributed into the following ten districts:—kingdom of Mexico, kingdom of New Gallicia, new kingdom of Leon, colony of New Santander, province of Texas, province of Cohahuila, province of New Biscay, province of Sonora, province of New Mexico, and the two Californias; and these divisions are still frequently used in the country. It is now divided into twelve intendancies, and three provinces, namely,

Under the temperate zone.	1.	Province of New Mexico.	North region.
	2.	Intendancy of New Biscay, or Durango.	
	3.	Province of New California.	North-west region.
	4.	Province of Old California.	
	5.	Intendancy of Sonora.	
	6.	Intendancy of San Louis Potosi.	North-east region.
Under the Torrid Zone.	7.	Intendancy of Zacatecas.	Central region.
	8.	Intendancy of Guadalaxara.	
	9.	Intendancy of Guanaxuato.	
	10.	Intendancy of Valladolid.	
	11.	Intendancy of Mexico.	
	12.	Intendancy of Puebla.	
	13.	Intendancy of Vera Cruz.	
	14.	Intendancy of Oaxaca.	South-west region.
	15.	Intendancy of Merida, or Yucatan.	

Some of these intendancies are ten, twenty, and even thirty times larger than others; while several of the least extensive contain above 100 times more inhabitants than the larger divisions. The following Table may be useful, as presenting in one view these striking inequalities of the distribution of Mexican population, even in the most civilized part of the kingdom.

Intendancies.	Extent in square Leagues.	Number of Inhabitants.	Inhabitants to the square League.
San Luis Potosi	27,821	331,900	12
Sonora	19,143	121,400	6
Durango or Biscay	16,873	159,700	10
Guadalaxara	9,612	630,500	66
Merida	5,977	465,700	81
Mexico	5,927	1,511,800	255
Oaxaca	4,447	534 800	120
Vera Cruz	4,141	156,700	38
Valladolid	3,447	476,400	273
Puebla	2,696	813,300	310
Zacatecas	2,355	153,000	65
Guanaxuato	911	517,300	568

The fundamental maxim of Spanish jurisprudence in Mexico and the other colonies is, to consider all these acquired dominions as vested solely in the crown, and as in a manner the personal property of the sovereign. This right is rested upon the bull of Alexander VI. which bestowed, as a free gift, upon Ferdinand and Isabella, all the regions that had been or should be discovered in America. From the Spanish monarchs all grants of land in that continent proceed, and to them they finally return. The leaders of the various expeditions, the governors of the different colonies, the officers of justice, the ministers of religion, are all appointed by their authority, and removable at their pleasure. The colonists are entitled to no privileges independent of the sovereign; and even in the largest cities the rights of the citizens are merely municipal, and limited to the regulation of their own internal commerce and police. All political power, every thing relating to public government, centres in the crown, and in the officers whom it has nominated. The viceroy of New Spain not only represents the person of the sovereign, but possesses all his regal prerogatives in their utmost extent, and exercises supreme authority in every department of government, civil, military, and criminal. He has the sole right of nominating to the principal offices, and of supplying those which are in the king's gift till the person whom he appoints shall arrive. His court is formed upon the model of that of Madrid, and displays an equal or even a superior degree of magnificence and state. He is aided in his extensive government by officers and tribunals resembling those of Spain; and though some of these are appointed by the sovereign, they are all subject to the viceroy's command, and amenable to his jurisdiction.

The administration of justice is vested in tribunals called audiencias, formed upon the model of the Spanish court of chancery. One of those, consisting of a number of judges, proportioned to the extent of the district, is established in every province, and takes cognizance both of civil and criminal causes. The viceroys are expressly prohibited from interfering in the decisions of these courts; and in some cases the audiencias may bring his political regulations under their review, and present remonstrances on the subject; or, finally, lay the matter before the king and the council of the Indies. Upon the death of a viceroy, the supreme power is vested in the audiencia of the capital till a successor be appointed, and the senior judge, assisted by his brethren, exercises all the functions of the vacant office. The sentences of these courts are final in every litigation concerning property of less value than 6000 pesos; but when the subject in dispute exceeds that sum, their decisions may be carried by appeal to the council of the Indies—a court which was instituted by Ferdinand in 1511, and brought into a better form by Charles V. in 1524. Its jurisdiction extends to every department of government in Spanish America, and all laws and regulations respecting the colonies must be approved by two-thirds of the members. All the officers nominated by the king are conferred in this council; and to its inspection every person employed in America, from the highest to the lowest, is held accountable. In this council the king is always supposed to be present, and its meetings are always held where he resides.

The leading object of the Spanish government has always been, to secure the productions of the colonies to the parent state, by an absolute prohibition of all intercourse with foreign nations. All that the colonies yield must be conveyed to Spanish ports, and all that they consume must flow from the mother country. No foreigner can enter the colonies without express permission; no vessel of a foreign nation is admitted into their harbours; and no inhabitant is permitted to trade with them upon the pain of death. More liberal measures have been gradually adopted; but much still remains to be done, which will probably be delayed till the colonies declare themselves independent, and consult for their own prosperity.

The ancient history and early institutions of Mexico are involved in almost impenetrable obscurity, and all that has yet been advanced on the subject, rests on no surer foundation than certain hieroglyphical paintings, which admit of the most various interpretations. The authenticity of these documents themselves is sufficiently questionable; and it is impossible to ascertain that they are either original, or faithful copies of originals, and not the fabrications of the Spanish monks, who are known (upon the usual principle of Roman Catholic missionaries) to have commended the truths of Christianity to their Indian subjects, by tracing a resemblance between the new doctrines and the old superstitions of the natives. The knowledge of events among the ancient Mexicans, was preserved by means of those knots and threads of various colours, called by the Peruvians *quippus*, and said to have been found also among the Canadians and Chinese. These very imperfect and unintelligible records were superseded by the use of writing and hieroglyphics only about A. D. 648, from which period alone, therefore, any tangible documents can be dated. These symbolical figures, however, though of a more permanent character than the knotted threads, are still of little service without the principles of their interpretation, which are very doubtfully preserved. But supposing both the record and the exposition to be undoubtedly established, there are only a few fragments in existence upon which the ingenuity of the antiquary can be exercised. These paintings being considered as monuments of idolatry deserving to be destroyed, were ordered by Zummaraga, the first bishop of Mexico, to be carefully collected, and committed to the flames. Whatever knowledge of remote events these rude monuments contained has thus been almost entirely lost; and the whole of our information must be derived from traditions, and the few remnants of those historical symbols which have escaped destruction. Collections of these fragments have been deposited in the libraries of the Vatican, Veletri, Vienna, Dresden, Berlin, Paris, and (as some have conjectured) of Oxford; but the most authentic and valuable are said to be those which are printed in Purchas's pilgrims These paintings are done on skins, cotton cloth, a kind of pasteboard, or on the bark of trees. These manuscripts were neither composed of separate leaves nor rolls, but generally folded in a zigzag manner like fans, with two tablets of light wood pasted at the ends. The manuscripts brought to Europe bear a great resemblance to each other, and are chiefly remarkable for great strength of colouring. The figures are mostly dwarfish in respect of the body, and remarkably incorrect in point of drawing. The heads are of an enormous size, the bodies extremely short, and the feet so long in the toes as to resemble the claws of a bird. The heads are always drawn in profile, while the eye is placed as if the figure presented a full view; and the noses are of a most disproportionate size. "Every figure," in short, (in the words of Dr. Robertson,) "of men, of quadrupeds, of birds, as well as every representation of unanimated nature, is extremely rude and awkward. The hardest Egyptian style, stiff and imperfect as it was, is more elegant. The scrawls of children delineate objects almost as accurately." Their uncouth forms may be considered, indeed, with M. Humboldt, as equivalent to the bad hand-writing of our literati; or as necessarily retained, as established symbols, in more civilized periods. But the confusion and obscurity of the whole system defy all explication; and leave no other source of information than those originally uncertain traditions in regard to the history of the nation.

According to these traditions, the Mexican empire had not been of long duration previous to the Spanish invasion. Their country, as they relate, was originally possessed by small independent tribes, whose manners and mode of life resembled those of the rudest savages. But, at a period nearly corresponding with the beginning of the 10th century of the Christian era, several tribes arrived by successive migrations from unknown regions towards the north and north-west, and being more civilized than the original inhabitants of Anahuac (the ancient name of New Spain) began to introduce the arts of social life. The Toultecs appeared first in the year 648; the Chichimecks in 1170; the Nahualtecs in 1178; the Acolhuecs and Aztecs in 1196. These nations, speaking the same language, and apparently proceeding from the same quarter, described themselves as expelled from a country lying to the north-west of the river Gila, brought with them paintings, which indicated the events of their migration; and gave the names of the cities which they had left to those which they first built after their arrival, namely, Huehuetlapallan, Aztlan, Teocolhuacan, Amaquemacan, Tehuajo, and Copalla. But their real origin still remains an inexplicable enigma in history. They are conjectured by M. Humboldt to have proceded from Tartary or China, and to have been a portion of those Hiongnoux, who, according to the Chinese historians, emigrated into the northern parts of Siberia, and part of whom pushed through Asia into Europe under the name of Huns. The era of the Toltec migration 544, about 100 years before their arrival in Anahuac, corresponds with the period when the ruin of the dynasty of Tsin occasioned great commotions among the nations in the east of Asia. But for all this, there is, in fact, no other ground than mere conjecture; and out of 83 American languages, carefully examined by competent judges, only 170 words have been found which could be traced to the languages of the old continent, namely, to those of the Mantchou Tartars, the Monguls, the Celts, the Biscayans, the Copts, and the natives of Congo. From whatever quarter they procceded, they are said to have brought with them the arts of hieroglyphic painting, of casting metals, and cutting the hardest stones. They introduced the cultivation of maize and cotton, built cities, made roads, and constructed pyramids. They had a solar year more perfect than that of the Greeks and Romans; and had a form of government, which shewed that their progenitors had experienced great vicissitudes in their social state. The last mentioned tribe, about the beginning of the 13th century, advanced from the city of Aztlan to the plains around the great lake of Mexico, where, after several years occupation of the spot, they founded the city of Mexico; but were still unacquainted with regal government, and were ruled in peace, or commanded in war, by such as were most entitled to pre-eminence by their wisdom or valour. But at length the supreme authority centered in one person; and, at the time of the conquest, Montezuma was the ninth monarch who had swayed the Mexican sceptre, not by hereditary right, but by popular election. This recent origin of the Mexican nation (which is indeed confirmed by their own want of historical traditions) is not easily reconciled with the high degree of civilization, which the Spanish accounts represent them to have attained at the time of the conquest; and it is highly probable that the splendid descriptions of their government and manners are considerably exaggerated. These accounts also are obviously so contradictory, and apparently so inaccurate, that no correct estimate can be formed of the state of society and progress of the arts in the Mexican empire, when it fell under the power of Spain. The extent even of the empire was represented by the conquerors in a very delusive light; and the dominions of Montezuma were spoken of as stretching over all the provinces of New Spain, from the Northern to the Southern Ocean. But a great part of the mountainous country north of the river Santiaga, was possessed by the Otomites and Chichemecs, a race of ferocious and uncivilized hunters, none of whom recognized the supremacy of the Mexican monarch. These tribes occupied the plains of Zelaya and Salamanca, now admired for their fine cultivation; and frequently extended their ravages as far as Tula, on the northern bank of the valley of Tenochtitlan. Even in the interior and level country there were several cities and provinces which had never submitted to the Mexican yoke; and the territory denominated Anahuac, between the 14th and 21st degrees of latitude, contained, besides the Aztec empire of Montezuma, the small republic of Chalollan, (Cholula,) within less than 20 leagues of the capital, and subjected to the Mexican crown only a short time before the arrival of the Spaniards; Tlaxcallan (Tlascala,) another independent and hostile state; Tezcuco (Tepeaca) and Mechoacan, two considerable kingdoms, whose frontiers reached within 30 or 20 leagues of Mexico, and the latter of which was remarkable for its implacable enmity to the Mexican name. The empire of Montezuma was thus bounded towards the east by the rivers of Guasacualco and Tuspan; and towards the west by the plains of Soconusco and the port of Zacatula; comprising only the modern intendancies of Vera Cruz, Oaxaca, Puebla, Mexico, and Valladolid, an area of about 15,000 square leagues.

The progress of civilization and state of society in this empire may be estimated by the following facts. 1. *The right of private property was fully understood;* and both property in land and property in goods might be transferred by barter, or descend by inheritance. Land was held by various tenures; by some it was possessed by full right, and it descended to their heirs; but by others it was enjoyed along with some office or dignity with which it was acquired or lost. These two modes of occupation were deemed noble, and were peculiar to the highest class. The great body of the people had only a share in the produce of a common tract of land, which was measured out in every district, according to the number of families, and was cultivated by the joint labour of the whole community; its produce deposited in a common storehouse, and divided among them according to their respective exigencies. 2. *The cities were numerous*, well inhabited, and, though doubtless greatly overrated in point of population and splendour, in the accounts of the conquerors, yet appear to have been of such importance as to indicate a considerable degree of progress in the arts of social life. The capital seems at least to have contained 60,000 inhabitants. 3. *The separation of the professions* had taken place to a considerable extent. The function of the mason, the weaver, the goldsmith, the painter, and several other trades, were carried on by different persons, who were regularly instructed in their respective crafts; and, by means of assiduous application to one object, they attained a degree of neatness and perfection beyond what could have been expected from the rudeness of their tools. Their various productions were brought to markets regularly held in the cities, and exchanged in the orderly intercourse of commerce. 4. *The distinction of ranks* was established by very wide intervals. The great body of the people was placed in a very humiliating state. A considerable number, named Mayeques, were attached to the soil, which they were bound to cultivate, and with which they were conveyed from one proprietor to another. Others were held in the most rigorous condition of domestic servitude, and their lives were deemed of so little value, that the murderer of any of them was not subjected to any punishment. Even those who were considered as freemen, and had their share of a common tract of land as above mentioned, were treated by the haughty nobles as beings of an inferior species. The nobles themselves were divided into various classes, with their peculiar titles, some of which descended with their lands to their families, and others were annexed to particular offices, and conferred for life, as marks of personal distinction. The respect due from one rank to another was prescribed with the most ceremonious accuracy, and incorporated itself with the expressions and idioms of the language, which is said to abound in terms of courtesy. The people were not allowed to wear the same dress, or to dwell in houses of the same form with those of the nobles, or to accost them without the most submissive reverence, while, in the presence of their sovereign, they durst not lift their eyes from the ground or look him in the face. The nobles themselves, when admitted to an audience with the monarch, were obliged to enter bare-footed, in mean garments, and with forms of homage approaching to adoration. 5. There appear to have been many *established laws and customs* circumscribing the power of the crown, previous to the election of Montezuma, who subverted the original system of government, and introduced a pure despotism. There were thirty nobles of the highest order, each of whom had about 100,000 people in his territories; and subordinate to these there were about 3000 nobles of a lower class. The jurisdiction of the crown was extremely limited, as in the times of feudal policy in Europe; and the nobles guarded their extensive privileges with the utmost jealousy, against the encroachments of the crown. The king could not determine concerning any point of general importance, such as making war and disposing of the revenue, without the approbation of a council composed of the principal nobility. The right of electing the sovereign seems to have been originally vested in the whole body of the nobles; but was afterwards committed to six electors. Generally, the choice fell upon some individual who was sprung from the royal family; and to the successive choice of able and warlike princes may be ascribed the extraordinary power which the empire attained in so short a period of time. Under Montezuma, the splendour of the Mexican court resembled the magnificence displayed in the ancient monarchies of Asia. 6. Considerable order and regularity were manifest in the *internal administration and police* of the empire. The crown exercised complete jurisdiction over its immediate vassals; and judges were appointed for each department, whose decisions are said to have been formed with a degree of order and equity resembling the practice of highly civilized societies. 7. For the support of government, *taxes* were laid upon land, upon the acquisitions of industry, and upon commodities of every kind; and were levied according to equal and established rules; but, as the use of money was unknown, these taxes were all paid in kind, and the public storehouses were filled with every kind of natural production, manufactured articles or works of art, from which the emperor supplied his attendants in peace, and his armies during war, with food, clothing, and ornaments. People of inferior rank, neither possessed of land, nor engaged in commerce, instead of taxes, were bound to render personal service, in cultivating the crown lands and carrying on public works. 8. Several *regulations of police* among them indicate a considerably improved state of government. The relays of couriers stationed at proper intervals, to convey intelligence from one part of the empire to the other; the structure of the capital in a lake with artificial dykes and long causeways erected in the water; the plan of their aqueducts, or conduits for conveying a stream of fresh water into the city along one of the causeways; the appointment of a number of persons to clean the streets, to light them by fires, and to patrole as watchmen during the night, are all marks of high refinement and order. 9. Their progress in various *arts* evinces most decisively the civilized habits which they had attained. They represented men, and animals, and other objects, by such a disposition of various coloured feathers, as is said to have produced all the effects of light and shade, and their ornaments of gold and silver have been also described as equally curious. At the same time, it is to be kept in mind, that the specimens of these ornaments and utensils deposited in the cabinet of the king of Spain, are affirmed to be very coarse and uncouth representations of the human form and other objects, and to be destitute both of grace and propriety.

The earliest and one of the most authentic specimens of those paintings, by means of which the Mexicans supplied their want of written records, was published, as has been noticed, by Purchas, in 66 plates, divided into three parts: the first of which (according to explanations obtained from the natives) contains the history of the Mexican empire under its ten monarchs; the second represents the tribute which each conquered town paid into the royal treasury; and the third is a code of their domestic, political, and military institutions. But, if we may judge from the specimens and explanations given by M. Humboldt in his American researches, nothing can well be conceived more clumsy in execution, more vague in the interpretation, or more uncertain as historical records, than these boasted devices. The more simple of these hieroglyphics represent a town by the rude delineation of a house with certain emblems, sometimes natural objects, and sometimes mere artificial figures, to distinguish one from another. Some of them are mere fanciful figures. A monarch, for instance, who had extended his empire by force of arms, is represented by a painted target, ornamented with darts, placed between his figure and the emblems of the towns which he had subdued. In designating numbers, they had reached the farther step of mere conventional signs, expressing a small number by so many circles as units, but assigning to large integral numbers their peculiar marks. A small standard or flag, for instance, represented 20, a feather 400, a sack 8000; and so on, says Clavigero, as far as 48,000,000. A flag, divided by two cross lines, and half coloured, denoted 10; and if three quarters were coloured it signified 15. A flag followed by three dots or points expressed 23, &c.

Their mode of computing time is considered as a more decisive evidence of their progress. Their civil year was a solar year of 365 days, and consisted of 18 months, each containing 20 days. The five intercalary, or rather supernumerary days, were considered as unlucky days, on which no work should be done, or sacred rite performed, and were devoted solely to amusement. The day was reckoned to begin at sun-rising, and was divided into four intervals, by the rising and setting of the sun, and its two passages over the meridian. Each month of 20 days was divided into four weeks of five days each. Thirteen years formed a cycle, to which they gave a particular name, and four of these constituted a period of 52 years, which they denoted by another term. Two of these periods of 52 years formed what they called an old age. At the end of 52 years, 13 days were intercalated to bring their time up to the seasons, which makes their year agree with the Julian period of 365 days and 6 hours, and discovers a considerable degree of philosophical accuracy.

A variety of considerations concur, on the other hand, in proving the civilization of the Mexicans to have been extremely imperfect. Their mode of carrying on war was altogether savage, and they fought chiefly to gratify their vengeance, by shedding the blood of their enemies. They estimated the glory of a victory by the number of prisoners; and all the captives were invariably butchered and devoured with the most barbarous excesses. Their funeral rites were equally bloody; and, on the death of any distinguished person, a certain number of his attendants were put to death, and buried in the same tomb.

Their agricultural productions were by no means so abundant as to furnish a plentiful subsistence to the nation; and various precautions were employed to prevent a rapid increase of population. There was little intercourse between the different provinces of the empire; and scarcely any roads to facilitate such communications. They were destitute of money, and of any universal standard for estimating the value of commodities. All their commerce was carried on by barter, except that nuts of cocoa (from which chocolate, the favourite drink of the higher ranks, was made,) had begun to be used as a medium of exchange.

Their architecture was altogether rude and imperfect; and, even in their larger cities, the houses were mere huts of turf and stone, thatched with reeds, and without windows. Nor do the public buildings and houses of the nobility appear to have been constructed of more durable materials.

The religion of the ancient Mexicans was of the most gloomy and revolting description. Their divinities were represented as delighting in vengeance, and were exhibited under the most detestable and horrifying forms. Their temples were decorated with the figures of the most ferocious and destructive animals with which they were acquainted; and fear was the only principle instilled into the minds of their votaries. The most rigid mortifications and excruciating penances were the means employed for appeasing the wrath of the gods; and the worshippers sprinkled the altars, as they approached, with blood, drawn from their own bodies. Human sacrifices were accounted the most acceptable of all offerings, and every captive taken in war was devoted as a victim to the deity. The head and heart were allotted to the idol, and the body carried off as a feast for the offerer and his friends. Under the influence of such barbarous superstitions and bloody spectacles, the spirit of the Mexicans became unfeeling, and their manners in many respects not less ferocious than those of the most savage tribes, who were far behind them in point of general civilization. Without losing the fiercer features of the wandering and independent Indians, they had fallen into many of the evils which attend the formation of political societies and large communities. When the Spaniards made the conquest of Mexico, they found the people in that state of abject submission and poverty which usually accompany a despotic government and feudal institutions. The higher classes alone possessed the more fertile lands—the governors of provinces indulged with impunity in the severest exactions—and the cultivators of the soil were every where degraded. The highways swarmed with mendicants; and, from the want of large quadrupeds in the country, thousands of the lower orders were employed as beasts of burden in conveying the maize, cotton, hides, and other commodities sent from the more remote provinces to the capital, in the payment of tribute.

There are few remains of Mexican antiquities to be found in the country. Even the hieroglyphic paintings are now so scarce, that the greater part of the well-informed persons who reside there have never seen any. Cortes, at the conquest, destroyed the temples, broke the idols, and buried three masses of stone, which were too large to be destroyed, that every thing belonging to the ancient rites might be concealed from the eyes of the people. Some of these stones have been recently discovered, and particularly one of an immense size, covered with sculpture, relative to the calendar. This was dug up in 1790, in the great square of Mexico, among the foundations of the temple of Mexitli. Its actual weight is 24 tons; and as no mountain within eight or ten leagues of the spot furnishes the same kind of porphyry, it must have been conveyed with immense labour to the foot of the sacred edifice. Another of a cylindrical form, and covered with figures in relief, was also found upon levelling the great square in Mexico, and is supposed to be the stone of sacrifices usually placed on the summit of the teocallis; but is conjectured by M. Humboldt to correspond rather with the account given of large stones, upon which the braver prisoners were condemned to sustain the combat of gladiators with a succession of Mexican warriors. Various other sculptures in relief, colossal statues, small clay vases, well-cast brass bells, &c. have been found in different places; and it is supposed, that upon due research being made, many more might be procured. But the principal and most prominent Mexican antiquities are the remains of the teocallis, or houses of the gods. These edifices were generally of a pyramidal form, rising, not by steps, but by a succession of four or five lofty terraces. On the summit were erected the temples, which served also as watch-towers, and in which were placed the colossal idols of the divinity, to whom the teocalli was consecrated; and to this platform a grand staircase on the outside afforded access.

The burial places of the kings and nobles were constructed within these pyramids, and around them were the dwelling places of the priests, with gardens and fountains enclosed by walls. These structures were frequently used as arsenals and fortifications, and are considered as bearing a striking resemblance to the Babylonian temple of Belus. The most remarkable of these edifices still existing are those of Teotihuacan, Papantla, and Cholula. The first are situated in the valley of Mexico, about eight leagues north-east from the capital, in a plain called the *path of the dead*, where there are two large teocallis, surrounded by several hundreds of smaller ones, forming streets in straight lines from north to south, and from east to west. Each side of the base of the largest measures 682 feet, and the perpendicular height 180 feet. The smaller pyramids are not above 30 feet in perpendicular height, and are supposed to be the tombs of the chiefs. The pyramid of Papantla, which was discovered only about the year 1780, by some Spanish hunters, is more tapering than any other monument of the kind, being only about 80 feet broad at the base, and about 65 in perpendicular height. It is built entirely with hewn stones of an extraordinary size, and regular shape; and has three staircases leading to the top. It is covered with hieroglyphical sculptures, and small niches to the number of 318 cut in its sides, and arranged with great symmetry. But the greatest and most ancient and most celebrated of these pyramidal structures, is the teocalli of Cholula, which, at a distance, has the appearance of a natural hill covered with vegetation. Its perpendicular height is 164 feet, and each side of its base 1440 feet. It is built of unbaked bricks, with alternate layers of clay; and on the platform is now erected a Catholic chapel, in place of the ancient temple of *the god of the air*. A few years ago a road from Puebla to Mexico was carried through the first terrace, which laid open a square room in the interior, built of bricks, and supported by cypress beams. The bricks were stepped over each other, the upper overreaching the lower, so as to meet in a point, and form a kind of Gothic arch, a mode of structure not uncommon in Egypt and India. This apartment had no outlet, but contained two human skeletons, several idols in basalt, and a number of curiously varnished and painted vases.

The history of the conquest of Mexico by the Spaniards has been already brought down, in the article Cortes, to the capture of Guatimozin, after the fall of his capital, in 1521. This memorable siege, which decided the fate of the Mexican empire, continued for the space of seventy-five days, with scarcely any interruption to the exertions of the assailants and defenders; and without the aid of the other Indian powers, all the superiority of the Spanish arms and discipline would not have been able to carry the place over the great abilities of Guatimozin, the number of his troops, and the peculiar situation of his capital. The exultation of the Spaniards in accomplishing this arduous enterprise was quickly damped by the inconsiderable amount of the spoil which they were able to collect amidst the ruins of the metropolis. Guatimozin, aware of his approaching fate, had ordered the remaining treasures in his possession to be thrown into the lake; and the Indian auxiliaries, while the Spaniards were engaged with the enemy, had carried off the most valuable part of the booty. To appease the discontent of the troops, and in compliance with their suspicions, Cortes was at length persuaded to subject the unhappy monarch and his chief favourite to torture, in order to force from them a discovery of the royal treasures, which they were supposed to have concealed. The prince resisted with invincible fortitude all the cruelty of his tormentors, but his fellow-sufferer expired under the violence of the anguish; and Cortes, at length ashamed of such barbarous proceedings, rescued the royal victim from the hands of his persecutors. The provinces of Mexico, after the fall of the capital, submitted to the conquerors without farther resistance; and small detachments of Spaniards marched without interruption in different directions to the shores of the Great Southern Ocean.

Even before any legal authority could be transmitted from the Spanish court, Cortes proceeded to exercise all the powers of a viceroy; and endeavoured, by various arrangements, to secure and improve the conquest which he had achieved. Having determined to establish the seat of government in its ancient station, he began to rebuild the ruined capital on a more extensive and magnificent plan. He employed skilful persons to search for mines, and encouraged his principal officers, by large grants of land and other privileges, to settle in the remote provinces. The natives, at times rendered desperate by their oppressions, ran to arms for the recovery of their liberties, but were uniformly overpowered by European discipline and valour. These efforts to regain their independence only served to aggravate their sufferings; and after every insurrection (which the Spaniards affected to consider as rebellion against a lawful sovereign,) the leaders were put to death by the most excruciating torments, while the common people were reduced to the state of personal servitude. In the country of Panuco, sixty caciques and 400 nobles were burnt at one time; and the families and relatives of the wretched victims were compelled to be spectators of their dying agonies. The captive prince Guatimozin, upon a slight suspicion of having devised a plot for shaking off the yoke, was ordered, without even the formality of a trial, together with two of the most distinguished chiefs of the empire, to be publicly hanged; and these acts of barbarity, coolly committed by Cortes and Sandoral, were readily imitated by persons of subordinate ranks in the perpetration of still greater excesses. The miserable Indians were every where dragged away to search in the rivers and torrents for the precious metals; but it does not appear that their avaricious oppressors profited greatly by their labours, and the early historians of America abound with accounts of the hardships and poverty of its conquerors. It was not till thirty years after the conquest, that the richer mines of New Spain were discovered; and that, under a more orderly government, more gainful researches were prosecuted.

Besides being dragged from their homes to labour in the mines, a great number of Indians were obliged to follow the armies, and to carry burdens above their strength, without sufficient nourishment or repose. In Mexico particularly, where a powerful and martial people made a more prolonged resistance to the invader, great multitudes fell in the field of battle. The introduction also of the small-pox, a disease unknown in the country, proved extremely fatal to the natives. By all these causes combined, the original inhabitants were rapidly diminishing in number. Numerous regulations were enacted by the Spanish government to protect the native Americans from the oppression of the European settlers; but all were ineffectual to restrain these rapacious and daring adventurers, when removed to so great a distance from the seat of authority. The Spanish ecclesiastics and missionaries exerted themselves incessantly for the protection of the natives, and are still considered by the Indians as their natural guardians, to whom they owe the various regulations enacted in their favour, and to whom they have recourse under every hardship to which they are subjected. One of the principal regulations intended for the protection of the Indians, but perverted to the very opposite purpose, was the system of *encomiendas*, by which the remains of the conquered race, instead of being left to be seized as slaves indiscriminately, were parcelled out in tribes of several hundreds of families, as grants to certain individuals as their protectors and proprietors. They were thus attached to the soil, and their work became the property of their masters, whose names they frequently assumed. But the evil thus only became worse, and more systematic; and it was not till the 18th century that the situation of the natives began to be ameliorated. As the families of these original proprietors became extinct, the encomiendas, being considered as fiefs, were not renewed. The viceroys, and particularly the audencias, watched over the interests of the Indians; and, in some provinces, their liberty and comfort have been gradually augmenting. Charles III. particularly, became their great benefactor, by annulling the encomiendas, and prohibiting the practices of the Corregidors, who were accustomed to supply the Indians with various articles at extravagant prices, so as to make them little better than slaves, by making them their debtors. But the establishment of intendancies, during the ministry of the Count de Galvez, in the beginning of this century, was the most memorable event in the history of Indian prosperity in New Spain, and, under the active superintendance of the intendants, the native race have begun to enjoy advantages and securities, of which they were deprived by the tyranny of the subaltern Spanish and Indian magistrates.

When the Mexicans had been brought to bear patiently the yoke of their conquerors, and the colonists had become tranquil possessors of all the treasures of the country, the warlike spirit insensibly declined, and the kingdom of New Spain, with the other settlements, enjoyed a peace of two centuries and a half. The internal tranquillity of Mexico has been rarely disturbed since the year 1596, when the dominion of the Spaniards was established over all the territories, from the peninsula of Yucatan and the gulph of Tehuantepec, to the sources of the Rio del Norte and the coast of New California. Disturbances among the Indians took place in 1601, 1609, 1624, 1692; and, in the last of these commotions, the palace of the viceroy, and some other public buildings, were burned by the insurgents. These disturbances, however, were occasioned chiefly by a deficiency of provision; and, as long as the native creoles were so few in number as to continue united with the European Spaniards, no spirit of independence appeared in the country. The first symptoms of such a spirit arose about the middle of the seventeenth century, after the commotions in New England; and, a few years before the peace of Versailles, the serious insurrection of Tupac Amaru, in Peru, alarmed the Court of Madrid with the apprehension of political commotions among the colonies; but it is only since the last thirty years that the colonists, having been brought, by greater freedom of trade, into contact with the United States, the British, French, and Danes, the political events in Europe, since 1789, have excited an interest among the Spanish creoles, and led them to aspire after their own rights as a people. The measures employed by the public authorities to quiet these agitations, particularly the prohibition of printing presses, even in towns of 40,000 or 50,000 inhabitants, and the proscribing of such works as those of Robertson, Montesquieu, &c.; the infliction of torture on several persons in New Grenada, suspected of revolutionary plans, and other similar instances of distrustful policy, served only to increase the discontents of the colonists. Nothing was done to forward their just demands, to improve the obvious defective institutions of the country, and to reform the most glaring evils of the colonial system; and in 1796, a great revolutionary commotion broke out in the province of Venezuela, which had nearly annihilated, in that quarter, the Spanish authority. The individual liberty which the colonists naturally enjoy, by their diffusion over a vast extent of country, and the mutual hatred of the different casts, especially the dread entertained of the blacks and Indians by the whole body of the whites, have prevented the popular discontents from spreading more generally in the other provinces. The events, particularly, which took place in S^t. Domingo, have contributed greatly to preserve tranquillity in the Spanish colonies on the continent. That tranquillity, however, has at length suffered an almost universal interruption, and insurrection has for several years, prevailed in every quarter of Spanish America. The progress of these revolutionary movements is still involved in too much uncertainty to afford any materials for a detailed account in this place, and would indeed far exceed the limits of the present article. There is less known, in this respect, of the events which have taken place in Mexico, than of any other Spanish settlement. Its secluded situation, the nature of its coasts, and its want of sea-ports, prevent any information from being received from the interior, except what the Spanish authorities may communicate. According to their accounts, all disturbances ceased in 1807; but various circumstances, particularly an intercepted letter from the Bishop of Valladolid, afford reason to believe that the country is full of insurgents, and that they are daily becoming better provided with the means of resistance. See Robertson's *History of America*, and Humboldt's *Political Essay on New Spain*. (*q*.)

MEZZOTINTO, is a kind of engraving which resembles drawing in China ink. Instead of the tedious and laborious operations of the graver, in highly finished plates, it is executed by a more simple and expeditious process in the following manner: The plate, with a piece of flannel under it, is to be laid on the table, and the grounding tool held perpendicularly in the hand.* While leaning moderately on it, the hand must be kept rocking in a right line from end to end, until the plate be wholly covered in one direction. Next let the strokes be crossed from side to side, and afterwards from corner to corner, working the tool each time over the whole plate in every direction, somewhat like the points of a compass; at the same time taking all possible care not to cut in one direction twice in a place. Thus the surface is covered completely with lines, and would produce a black impression if printed. Next, the designed effect is to be given by removing such parts of the surface as are necessary for light or sunshine. After the ground has been laid, the scrapings of black chalk are to be rubbed over the plate with a rag, or it may be smoked with candles. The drawing to be engraved is now to be traced on the plate, after having rubbed the black with red chalk dust. The lights and shades are to be produced by marking the outlines with a blunt needle, and scraping off the lights in every part of the plate as clean and smooth as possible, in proportion to the strength of the lights in the drawing, observing to preserve the outlines. Then the extreme light parts, such as the tip of the nose, the forehead, or lines, are to be softened or rubbed down with the burnisher. When an impression from the plate is dry, it should be touched with white chalk, where it ought to be light, and with black where darker; and the plate being retouched, the same course must be followed for the lights; and employing a small grounding tool for bringing the shades to a proper consistence. It is necessary to take successive proofs until the requisite quality be obtained.

By another method, the outlines of the object to be represented are etched, as also the folds in drapery, making the breadth of the shadows by dots, which must be bit to a proper depth by aquafortis. The ground used in etching is taken off, and the mezzotinto ground being laid, the scraping proceeds as before. Imison, *Elements of Science and Art*, vol. ii. p. 360.

Instead of following the manual operations of laying the ground of a mezzotinto engraving, Mr. Dossie has suggested that it may be attained with greater ease and accuracy by some mechanical means, and recommends the invention of a machine for that purpose. Vol. ii. p. 174. In his work are copiously detailed the whole process of engraving in mezzotinto, its uses and effects. It is there remarked, that "the principles on which the fitness or unfitness of subjects of this kind of engraving are founded, are of two kinds; the one respecting light and shade, the other the nature of the design with regard to the outline. Such pieces as contain large and clear masses of light do not succeed at all; but where, on the contrary, there is a large proportion of very dark parts, as in the representation of night scenes, or a large proportion of brown shades, as in the pictures of Rembrandt, Benedette, and Teniers, in some instances the best effect is produced, and with the least labour. Such pieces likewise as are of a simple composition, and do not require great force and variety of expression in passion and character, are suitable. But where great spirit is required to give merit, this manner of engraving fails, as it does not admit of those sharp and delicate strokes and touches which are the means of that expression." It thence appears, that mezzotinto engraving is best adapted to objects of considerable size. Nevertheless, some persons, such as Mr. Gilpin, incline to bestow greater qualities on it than it seems to deserve. It appears, indeed, that artists in general are disposed to elevate engraving to a higher rank than belongs to it. They wish it to be considered an original, not an imitative art. But what more is the most refined painting than mere imitation? It is either the description of real, or the representation of imaginary subjects. Engraving apparently holds a second place.

Facility of execution has been one principal means of diffusing mezzotinto engravings, while novelty has proved their recommendation. It appears, however, that what is susceptible of the greatest delicacy must be viewed as the most perfect. Mezzotinto has been more successfully cultivated in England than elsewhere, whence it is called on the continent the black or *English style*.

Evelyn ascribes the invention of this manner of engraving to Prince Rupert, Count Palatine of the Rhine, by whom he was acquainted with the method of executing it. But what he says is given under an air of great mystery, and he declines publishing the process, though expressing himself willing, privately and with permission of the Prince, to impart it to any "curious and worthy person." The author was at the same time furnished with the plate of a head engraved by the Prince, which is inserted in his work, *Sculptura, or the History and Art of Chalcography*. Chap. vi. Baron Heineken, however, refuses him this credit; and indeed both he and a later author, Huber, bestow it on Louis de Siegen, or de Sichem, a lieutenant-colonel in the service of the Landgrave of Hesse Cassel, who produced a mezzotinto print of the Princess Amelia, in folio, in 1643. Prince Rupert, having learned the method from him, imparted it to Wallerant Vaillant, a Flemish painter and engraver, on a promise of secrecy. But it was soon disclosed by the indiscretion of one of the workmen employed in preparing the copper. The engraving by Siegen is some years anterior to the date of Evelyn's publication. See Heineken, *Idée Générale d'un Collection des Estampes*, p. 208, Note. Huber, *Notice Generale des Graveurs*, p. 59. (*c*.)

MICHAELIS, John David, a celebrated German theologian and biblical critic, was born at Halle, in Lower Saxony, on the 27th of February, 1717. He received the rudiments of his education at the school of

* The *grounding tool* is like a steel chisel, the edge of which has a semicircular form, and is cut into very fine teeth. It is fixed into a wooden handle.

the Orphan House, and was chiefly indebted for his instruction in classical literature to his father, Christian Benedict Michaelis, professor of theology and the oriental languages in the university of Halle. He took his degree of master in the philosophical faculty at the university above mentioned, in the year 1739. In 1741, he made an excursion through Holland and England, and formed an acquaintance with those eminent orientalists, Schultens and Lowth. During his residence in England, the Bodleian library at Oxford presented a rich field for his indefatigable researches. After an absence of fifteen months he returned to Halle, where he delivered lectures on the historical books of the Old Testament. In 1745, he repaired to Göttingen, under the patronage of M. de Munchausen, where he continued his lectures, and was first appointed an extraordinary, and, in 1750, an ordinary professor in the philosophical faculty in that university. Here he had an opportunity of cultivating his talents, and extending his knowledge by assiduous study, and by a constant intercourse with Haller, Gesner, Mosheim, and other eminent scholars. He also obtained the situation of secretary to the Royal Society of Göttingen, of which he became director in 1761; and he was soon afterwards created an aulic counsellor by the court of Hanover. As his reputation increased, he was admitted, as an honorary or corresponding member, into various learned bodies in foreign countries.

The talents of Michaelis were no less usefully employed in the composition of various learned works, than in the zealous performance of his duties as a public teacher in the university. His critical researches into the scriptures of the Old and New Testament merit particular notice. When we consider the small aid he could derive from the labours of his predecessors, his illustrations of the Old Testament may be viewed as an almost entirely original work; and his introduction to the scriptures of the New Testament, although less valuable, perhaps, in a philological point of view, is still esteemed, in its last amended form, as an indispensible repertory of critical learning for every student of theology. His translation of the Bible, which was undertaken at the suggestion of Lessing, is chiefly valuable on account of the notes. His *Compendium Theologiæ Dogmaticæ*, which excited little sensation in Germany, was confiscated in Sweden; but Count Höpken, some years afterwards, endeavoured to repair the injury thus done to the learned author, by prevailing upon the king of Sweden to confer upon him the order of the Polar Star. The extensive knowledge which he had acquired in biblical philology, as well as in every department of learning connected with the study of the Scriptures, enabled him to form very accurate notions on the subject of the original and peculiar civil institutions of the Hebrews, which he published to the world in his treatise on the Mosaic law; a work which affords equal instruction and entertainment to the statesman, the historian, and the antiquary.

During a period of forty-five years, Michaelis continued to discharge his duties as a professor in the university of Göttingen with distinguished success and increasing reputation, by delivering lectures on various parts of the sacred writings, and communicating instruction in the Hebrew, Arabic, and Syriac languages. Towards the close of his life additional honours were conferred upon him. He was elevated, in 1786, to the rank of a privy counsellor of justice by the court of Hanover; and, in 1788, he was unanimously elected a fellow of the Royal Society of London. His laborious and useful life was terminated on the 22d of August, 1791, in the 75th year of his age.

We have already alluded to several of the works of Michaelis; and our readers will find a list of his various writings, which bear honourable testimony to his great learning and industry, in the *Gentleman's Magazine* for March 1792. A translation into English of his *Dissertation on the Influence of Opinions on Language*, was published in this country in 1772: and his *Introduction to the New Testament* was translated by Dr. Marsh, now Bishop of Llandaff, and published with Notes, &c. in 4 vols. 8vo. London, 1802.

MICHIGAN Lake, a large lake in the United States of America, is situated between 42° and 46° of North Latitude. It is of an oval form, about 260 miles long from north to south, about 945 in circuit, and has an area of nearly 10,368,000 acres. It runs into Lake Huron, and it is said to be unfathomable. The banks of the lake are thinly covered with pine, cedar, and shrub oak. It abounds with excellent fish, and trouts are sometimes found which weigh from 60 to 90 lbs. It is navigable for vessels of 400 tons. Lake Michigan is separated by a barren tongue of land from Lake Superior. See Morse's *Geography*, p. 63, and Warden's *Account of the United States*, vol. i. p. 71.

MICHIGAN TERRITORY.

Situation and *Boundaries*. The states of Indiana and Ohio, south; lake Michigan, west and north west; the Straits of Michilimakinac, north; lake Huron, north-east; and the river St Clair, lake St. Clair, Detroit river, and lake Erie, east. The southern extremity of Michigan is in N. Lat. 41° 37′, and its northern in N. Lat. 45° 41′.

Extent and *area*. Its greatest length from north to south, is, from Fort Michilimakinac to the N. W. angle of the state of Ohio, 286 miles; its greatest breadth from east to west, is. from the mouth of St. Clair river, to lake Michigan, 174 miles. From its irregular form, it is difficult to estimate with precision, the area in square miles of the peninsula of Michigan, but, approximating by the rhumbs, 34,600 will not differ more than a very small fraction from its real superficies. This is equal to 22,144,000 English, or U. S. statute acres. This extent exceeds considerably, the estimates formerly made in our common geographical works; but arises from now placing lake Michigan in its true position, nearly S. W. and N. E; this lake, until found otherwise by recent and more accurate observation, was considered as extending north and south, and was consequently erroneously delineated on most maps upon which it was placed, and of course the peninsula too much contracted.

Features. The peninsula of Michigan is an extensive table land, resting upon a vast stratum of secondary rock, composed of limestone and argillaceous sandstone. This structure imposes a peculiar physiognomy upon the country. The interior towards the sources of the rivers, is generally level and interspersed with lakes and morasses. The rivers, near their sources, are sluggish in their courses; deep and muddy beds give them a monotonous and disagreeable appearance; these characteristics vanish as the streams advance towards their respective places of deposit, from the following cause. A narrow border, or inclined plane of about 20 miles width, skirts the whole territory, from its south-east angle on lake Erie, to its south-west on lake Michigan. As the rivers approach this declivity, their currents become more rapid, and in most instances fall over precipices of secondary rock, and again become sluggish a few miles before entering their final deposit. Along the entire extent of this plain, the lands are fertile, generally rolling, well wooded, and extremely well adapted to agriculture. Its length being near 700 miles, and breadth averaging 20 miles, yields an area of 14,000 square miles, or nearly 9,000,000 of acres. In the interior, particularly towards the N. W. part of the peninsula, prairies, (*natural meadows*,) are common and extensive. Marshes, in many places, border the mouths of the rivers, but do not extend far inland. But though lakes, prairies, marshes, and cultivated fields occur, and diversify the aspect of the country, they are collectively limited in extent; more than seven-eighths of the whole peninsula is yet covered with a dense forest.

Lakes, *Bays*, *Islands*, and *Rivers*. In marking the boundaries, we have noticed the large lakes of Michigan, Huron, St. Clair, and Erie, which respectively serve as part of the limits of the peninsula of Michigan (*which articles see.*) In the interior, a very great number of small lakes exist, but not individually of sufficient importance to merit particular notice. Maumee bay, formed by the mouth of Maumee river, is about 8 miles long and 3 wide, with 7 feet water on the bars. A small island in form of a crescent, three-fourths of a mile long and about 100 yards wide, lies in the mouth of this bay, consequently it has two channels of entrance. The N. W. part of lake St. Clair, has received the name of Anchor bay, but possesses no particular feature deserving notice.

Saguina bay is the most remarkable of all those which indent Michigan. This is an immense opening from lake Huron, of upwards of 70 miles in length, and gradually narrowing from 35 miles in width, to a small river of the same name, whose sources are on the interior table land; the general range of Saguina bay is from N. E. to S. W. bordered by excellent land.

Traverse bay extends itself from lake Michigan, at N. lat. 45° 10′, and penetrates the country in nearly a south direction about 40 miles, where it contracts into a river of the same name. It is very remarkable that the eastern shore of lake Michigan, from the mouth of Traverse bay to that of Calumet river, at its southern extremity, is without bays, and presents the most dangerous navigation of a similar extent in all the Canadian sea.

In the S. W. part of lake Erie, a number of small islands exist, all of which have received distinctive appellations. Though these islands are not yet definitely assigned to any particular territorial section, yet from their proximity to Michigan, we have deemed it correct to enumerate them in the recapitulation of the natural features belonging to that country. Bass Islands is a group containing three larger and four smaller islands; the three larger Bass islands, lie nearly north and south of each other, and are about two miles long and half a mile wide each. In the southern Bass island, on its northern side, is the fine and commodious harbour of Put-in-bay, six miles west of which, on Sept. 10th, 1813, the British fleet, under Commodore Barclay, was defeated and captured by Commodore Perry. The Hen and Chickens, are four very small islands lying near each other, six or seven miles N. W. of the Bass Islands. The Hen and Chickens are unimportant, except as land marks in navigating lake Erie. The west, middle, and eastern Sisters, are three islands which, though designated as relatively north and south of each other, in fact range in nearly a S. W. and N E. direction; they are all small, neither exceeding 15 or 20 acres in extent, are well wooded, and about ten miles apart, and serve as excellent land marks to navigators on the circumjacent parts of the lake. The eastern, or rather north-eastern Sister, is fifteen miles S. E. from the mouth of Detroit river.

Celeron, Gros Isle, Bois Blanc, Grand, (*large*) and Petite, (*small*) Turkey Islands, Hog, and Peach Islands, all lie in Detroit river. Gros Isle, and the larger Turkey island, contain considerable bodies of good soil, upon which are several farms Bois Blanc deserves notice, only from its position, lying opposite Fort Malden, or rather the village of Amherstberg in Upper Canada, and having the main, and indeed the only ship channel (not more than 300 yards wide) into Detroit river, between it and the Canadian shore; its possessors must command the ingress and egress of the navigation of that important pass. The other islands in Detroit river are undeserving of particular notice. The river St. Clair, at its entrance into the lake of the same name, divides into a number of channels, forming intermediate islands; but being generally low, flat, and marshy, are of no consequence in a geographical point of view.

Michilimakinac is a small, but very important island, lying in the Strait between lakes Huron and Michigan. The United States have a fort and factory upon this island. There are a number of other islands in the Strait between lakes Huron and Michigan, and contiguous to Michigan, in each of those lakes, along their respective shores, but are uninhabited and unimportant.

The rivers of Michigan are numerous, and, compared with their length, of course, of large volume. The most remarkable of those which flow from the interior, are, Maumee, Raisin, Huron of Erie, Riviere aux Ecorces, Riviere Rouge, Huron of lake St. Clair, Belle riviere, Pine river, Saguina, Grand, Traverse, Marguerite, Mastigon, Grand Maremec, and St Joseph's rivers. Before, however, noticing the streams flowing from the interior, Detroit, and St. Clair rivers, and the Strait of Michilimakinac demand previous attention. The immense mass of waters pouring into lake Michigan, so much more than counterbalance the diurnal evaporation from its surface, that a strong and perpetual current passes from Michigan into Huron, through the Straits of Michilimakinac. The body of water in lake Huron, augmented by the overwhelming discharge from lakes Superior and Michigan, together with its own particular smaller confluents, gradually contract into St. Clair river, passes Fort Gratiot, by a strong rapid, which gradually subsides into a placid stream, flowing nearly south, about three-fourths of a mile wide, and twenty-six miles in length. It is a singular feature in the topography of the country under review, that St. Clair river assumes, at its point of discharge, all the peculiar features of the Deltas, of the Nile and Mississippi rivers. Detroit river commences at the S. W. angle of lake St. Clair, and running six miles and a half nearly in a west direction, passes the city of Detroit, by a channel of three-fourths of a mile wide. Opposite the city of Detroit, the river is narrower than it is in any other part of its course. Below the city, the river winds three and a half miles S. W. to the mouth of the Riviere Rouge (*Red River*,) thence turning to the south, gradually widens, and in a distance of eighteen miles from the mouth of Riviere Rouge, to that of Huron of Erie, expands to five miles in breadth at its junction with lake Erie. Vessels drawing seven feet water, pass without difficulty from lake Erie, through the intermediate straits and lakes, into Huron and Michigan, and towards lake Superior as far as the falls of St. Mary.

Of the rivers we have enumerated as flowing from the interior table land, only those upon whose banks civilized settlements have been made, are adequately known, or deserve notice in a brief review. Maumee river rises in the states of Ohio and Indiana, has only its discharge in the territory of Michigan; it is of importance in the topography of the latter, as forming its S. E. commercial entrance. Riviere Raisin (*Grape river*) rises in the interior uncultivated wilds; is about 150 miles in length, including windings, and for fifty miles above its mouth about 90 yards wide. Six miles above its mouth, it is precipitated over rapids or rather falls. A bar at its mouth prevents the entrance of vessels drawing more than two feet water. The lands on this river are of very excellent quality; timber, oaks of several species, sugar maple, linden, yellow wood, (*Liriodendron tulipifera*,) hickory, ash, and many other trees. Settlements are extensive, and farms well cultivated, near the mouth of the Raisin; this river falls into lake Erie, thirty-five miles from the city of Detroit. Huron of Erie is one of the largest and longest streams which rise on the table land of Michigan. This river has many confluent branches which interlock with those of Grand river flowing into lake Michigan. The Huron, including its windings, exceeds two hundred miles in length; its breadth, seventy or eighty miles above its mouth, 80 or 90 yards. Its shores are extremely fertile, producing nearly similar timber trees with those of the Riviere Raisin. It may indeed be observed, in order to avoid repetition, that the forest trees which enrich and adorn the borders of the rivers and lakes of Michigan, are generally of similar genera and species. Huron of Erie enters the latter, at the mouth of Detroit river; admits vessels of four feet draught four miles to its fifth rapid. Both banks are settled for twenty or twenty-five miles above its mouth; soil productive; surface hilly, or rather rolling, on its S. W. side; more level and sandy on that of the N. E. Riviere aux Ecorces (*Bark river*) is in reality only a creek, not more than 20 miles in its entire length, entering Detroit river opposite Grand Turkey island, three miles below the mouth of the river Rouge; but gains importance from the excellence of the land it waters, and the extensive farms which chequer the shores of all its branches. This small stream contains one of the most wealthy and compact settlements yet made in Michigan Territory. Riviere Rouge (*Red river*) rises about twenty-five miles in a direct line, nearly north from the city of Detroit, curves to the south-west, south and south-east, falls into Detroit river three and a half miles below the city of Detroit. The entire length of this small river, including all its windings, does not amount to fifty miles; its breadth, in no part of its course, more than 45 yards. The soil it drains is, however, a compensation for the brevity of its volume. More than one half of all the civilized inhabitants of Michigan, exclusive of those in the city of Detroit, are found upon the banks of the Riviere Rouge, and those of its branches. From the peculiar course of this river, being upon the inclined plane, sloping from the interior towards Detroit river; its banks are every where sufficiently dry and elevated for cultivation.* Huron of St. Clair rises on the interior table land, is a stream of magnitude, but little, if any, inferior to that of Huron of Erie. Huron of St Clair has interlocking branches with Riviere Rouge, Huron of Erie, Grand river, and the streams which flow north into lake Huron, and Saguina Bay. The settlements yet made on this river, are near its mouth, though the soil it waters yields, in no respect, to any part of the Michigan peninsula; it is navigable for vessels drawing three feet water twelve miles, where rapids occur. New settlements are extending along this river, and a new town, Mount Clemens, laid out (1818) five miles above its mouth, on its northern bank. Saline and Swan rivers enter Anchor Bay N. E. of the mouth of Huron river; Belle riviere, Pine river, and river Delude, fall into St. Clair river. None of these latter streams are of sufficient importance to merit particular description; upon all, settlements are formed, and the soil productive.

It would be useless to swell this article, by detail on the other rivers of Michigan, whose shores are yet wilderness, and whose courses, sources, and length, are of course but imperfectly known; we therefore only mark their names, and leave their description to a period of future geographical discovery.

Soil and *productions*, *vegetable* and *mineral*; *seasons* and *climate*. We have already observed, in our notice of its rivers, that the soil of Michigan was generally fertile; we may here repeat, that except where rendered otherwise by marshes, or flats too level to enable nature to drain the water accumulated by rain, that the soil of Michigan is, in a high degree, adapted to all the purposes of agriculture. If one half the area of the peninsula is deducted as unproductive, and this is certainly too large an allowance, yet 17,300 square miles, or 11,072,000 acres remain capable of cultivation. It ought to be carefully noted also, that most of that part of the surface which is really too low and wet for culture is thickly wooded, therefore completely subservient to the various purposes of human enjoyment and convenience, where wood is demanded. It may also be observed, that Michigan exceeds in extent New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island taken together; lies in a similar climate, and certainly, in comparative extent, contains more productive soil than exists on all the combined area of the latter

* The United States have a ship yard, four miles up this river, to where vessels drawing 16 feet water can ascend; a peculiarity which distinguishes it from all the other rivers of Michigan, whose sources are in its interior; not one of which yet explored, affords half the depth. Vessels drawing three feet, ascend the river Rouge eight miles above the ship yard.

states. By the census of 1810, those states possessed a population of nearly 1,243,000 persons, upon a surface of 31.200 square miles; therefore, if the peninsula of Michigan was peopled only equal to those less productive states, or about 40 inhabitants to the square mile, it would contain 1,384,000 souls. This estimate may, and no doubt will, excite surprise, but we are convinced falls short of the real capability of that too little known, but really fine region.

It would swell this article much beyond its due extent, to enumerate the various natural productions of Michigan. Of minerals or fossils, the nature of the country precludes much variety. Carbonate of lime is the most important, and indeed the only extensive mineral production yet discovered; this rock is found to underlay the Bass Islands, and many other parts of the country.

Of timber trees, perhaps no section of the United States possesses a more extensive and richer variety. Three or four species of oak; as many of hickory and walnut; ash, linden (*tilia*), sugar maple, red maple, elm, and white poplar (*liriodendron tulipifera*), may be enumerated as the principal species. Underwood and vines are numerous, and in many places render the extensive forests almost impervious. This circumstance alone attests strongly the natural fertility of the soil.

The native grasses in the praries and marshes are of various species, and are succulent and excellent for pasturage. The most valuable vegetable production of Michigan, and perhaps of all the northern parts of this continent, is the fols avoine, *zizania aquatica*. This elegant grass has received a misnomer from the pedantic repetition of European names. In fact, it specifically differs as much from oats or rice, as do the latter from each other, and can be compared with either, only as having a panicle as its mode of inflorescence. The Fols avoine covers the marshes near the margin of the lakes and rivers, and no other gramina, not even wheat, has so fine and beautiful an appearance when in bloom or ripe. Its grain is elongated, full, sweet, and nutritious. In a future density of population, the importance will appear of a cereal gramina, vegetating spontaneously where no other useful vegetable can, without the utmost exertion of human labour, be made to exist. The extent of North America, where this excellent native grain is found, almost exceeds belief. From Louisiana to the Arctic circle, it exists upon the streams and lakes, in a greater or less quantity; but the Canadian sea about N. Lat. 45, appears to be its most favourite residence.

Of exotic vegetables introduced into Michigan, all have succeeded which were suitable to the climate. Wheat, rye, oats, barley, flax, hemp, garden vegetables, and meadow grasses flourish. Neither farming, gardening, or the management of meadows and orchards, are pursued with even tolerable skill by the inhabitants; the beneficence of nature has to supply what is left undone by human ignorance and improvidence. Fruit, such as peaches, apples, cherries, and plums, are plentiful and delicious, maugre defective husbandry. In brief, the rude essay already made, amply demonstrates that population, science, and industry are only wanting to render Michigan one of the most flourishing and desirable sections of the United States.

A common observation is made, that the climate of Michigan is more mild than that of similar latitudes more to the eastward, towards the Atlantic coast. We are inclined to consider such an opinion founded upon erroneous principles. Lake Erie is only 565 feet above the Atlantic ocean, and no part of Michigan is perhaps 150 feet above the surface of Erie, or much more than 700 feet above the level of the Atlantic ocean; whilst much of the intermediate space is double that elevation, and consequently much more subject to the action of frost. The rivers and lakes of Michigan are, however, annually frozen; snows are heavy and lie long upon the earth, a circumstance in itself in a high degree salutary to fruit trees and small grain. The climate, in brief, differs in no essential respect from that in similar latitudes, elevation, and exposure. The summers are often oppressively warm, which, acting upon such extensive masses of fresh water as almost encircle the country, and cover much of its surface, exposes the inhabitants to intermittents, and other complaints in autumn. The climate is, nevertheless, in general salubrious, and the inhabitants healthy.

Animals. The land animals found native, were the elk, deer, bear, wolves, foxes, wild-cats, &c. Innumerable flocks of migratory water fowl, such as geese, ducks, swan, teal, and some others, cover the extensive marshes and ponds of Michigan at the approach of winter, in search of the fols avoine, and a milder climate. The same may be said of the wild pigeons, which often visit this country in countless thousands.

The fisheries in Erie, Huron, and Michigan lakes, compose a very important part of the domestic policy of the inhabitants of Michigan, as at once affording employment and subsistence to a large portion of their number. The fish usually caught are, the white fish, and salmon trout; both of exquisite flavour and taste. Many other species are however caught, of excellent quality.

Domestic animals, introduced into the country, are the same as found in every other section of the United States, and therefore need no particular mention.

Inhabitants, towns, government, counties, population, and *historical epochs.* The first civilized inhabitants of Michigan were Canadian French, from Montreal and elsewhere. A small trading post was formed at Detroit, long before the final conquest of Canada by the British, in 1759. After that event, the post at Detroit was continued by the conquerers. The original French remained, and their descendants multiplied, and now compose more than a moiety of the population of the territory. The residue is composed of a medley of emigrants from the United States, Canada, and Europe. The manners of the people are mild and affable. Education is neglected, and literary information confined to a few. The people who inhabit Michigan, are the most detached portion of the inhabitants of the United States; their external intercourse is very limited, which perhaps superinduces an indifference for those intellectual endowments which confer marked superiority on those who possess their advantages. Extended and approximating population will remove this, and many other evils, against which our frontier inhabitants have to contend.

The only town yet formed in Michigan worthy of particular description, is the city of Detroit, which is situated in Wayne county, and stands upon the right bank of the strait or river of the same name; N. Lat. 42° 15′ 36″—W. Long. from Washington City 5° 36′—or 82° 36′ W. from Greenwich. Detroit contains about 200 dwelling houses, and about 1200 inhabitants; a number of taverns and stores; one church, a court-house and jail, and an academy. The site of the city rises by a gentle acclivity from the river to the main street, and thenc extends backwards level, or very gently rolling. Being the *entrepot* between the United States and Canada, and the interminable Indian country in the interior of the continent, a military and naval post, and the seat of territorial government, more activity prevails at Detroit than could be expected from its remote and isolated position. It is in reality a thriving and prosperous town.

Munroe on the riviere Raisin in Munroe county, Browpstown above the mouth of Huron of Erie, and Maguaga in Wayne county, and Mount Clemens in Macomb county, have received the appellation of towns, though neither have assumed adequate importance to merit farther notice in this review.

The government of Michigan is that of the first grade of territorial administration. The governor and two judges adopt laws, and concentrate the legislative and highest juridical power in themselves. By a special act of congress, the territory has a delegate who sits in the house of representatives, with liberty of debate without power of voting. The ordinary minor subjects of judicial interference, are adjudged by courts of quarter sessions, composed of justices of the peace, who act in their individual capacity in the same manner as such officers act elsewhere in the United States.

The counties of Munroe, Wayne, and Macomb, embrace nearly all the settled parts of Michigan. The county of Munroe embraces the south-east parts of the territory as far as the river Huron of Erie; Wayne the region adjacent to the city of Detroit; and Macomb the extent along Lake St. Clair, and St. Clair river; each of those counties extend indefinitely westward. Some other counties have been named, such as Saguina, Michilimakinac, &c. but their extent and limits are too vague and precarious to merit farther notice.

By the census of 1810, the population of Michigan was made less than 5,000; this enumeration was, there is no doubt, much too confined; the territory, in August 1818, we are well assured, contained at least 10,000 persons, notwithstanding the very limited emigration in its favour, and the disasters of the last war between Great Britain and the United States, which fell with so much weight upon this section of country.

The historical epochs in which Michigan is particularly interested, are—Its original settlement by the French previous to 1760; occupation by the authorities of Great Britain to 1796; its occupation by the United States, separation from the N W. territory, and creation into a territory bearing the present title, 1802; General Hull's invasion of Canada, July 11th, 1812; battle of Brownstown, August 4th, 1812; evacuation of Canada, August 7th, 1812; battle of Maguaga, August 9th; and surrender of the city of Detroit, and territory of Michigan, to General Brock, August 16th, 1812; battle of Erie, and capture of the British fleet, September 10th, 1813; re-conquest of Michigan by the United States army under General Harrison, September 30th, 1813; battle of the Thames, and close of military operations in that quarter, October 5th, 1813; admission of a delegate from Michigan on the floor of Congress, at the session of 1819—20.

We may conclude this article by observing, that though the United States' posts at Green Bay and Prairie du Chien are, for civil purposes, put under the jurisdiction of the government of Michigan, we confined our notice to the peninsula, properly so called, as a connexion with those distant places is merely temporary, and must cease, when Michigan assumes her rank as a state of the United States.

DARBY.

MICKLE, WILLIAM JULIUS, celebrated as the translator of the Lusiad of Camoens, was born in 1734, at Langholm in Scotland, and was the son of the minister of the parish. After receiving a good education at the High School of Edinburgh, he went to London in 1763, and carried with him his poem "On Providence," which gained him the friendship of Lord Lyttleton. He was then employed as corrector of the Clarendon press at Oxford, and in 1767 he published his poem, called "The Concubine!"

His great work, the translation of the Lusiad, was printed in 1775, and contained an account of the Portuguese conquests in India, a life of Camoens, and a dissertation on the Lusiad. In 1779 he was appointed secretary to Governor Johnson, when he received the command of the Romney, and he was left at Lisbon as government agent for prizes. In that capital he was received with much attention as the translator of their great poet, and was admitted a member of the Royal Academy of Lisbon. Here he wrote his poem of "Almada Hill," an epistle from Lisbon. Having acquired some property, he returned to England, and settled at Whitby, near Oxford, where he died in the year 1769. His poems were published in 1794, in one volume, 4to.

MICROMETER.

THE word MICROMETER, from the Greek words μικρος, small, and μετρον, a measure, is the name given to an instrument for measuring small angular distances in the heavens, or small rectilineal spaces of any kind.

The micrometer was invented by our countryman, Mr. Gascoigne, about the year 1640-1, at which time he drew up an account of it in a letter to Mr. Oughtred. It consisted of two pieces of brass, ground to a very fine edge, and their edges were made to approach to or recede from each other, by a mechanical contrivance. Mr. Gascoigne had made use of it for several years in measuring the diameters of the moon and planets, in ascertaining distances at land, and in many nice astronomical observations. According to Mr. R. Townley, into whose hands one of these micrometers fell, a foot could be divided into 40,000 parts. Mr. Gascoigne had prepared a Treatise on optics for the press, but he was killed during the civil wars, in the service of Charles I. The MS. of this treatise was never found.

It appears from the Ephemerides of the Marquis of Malvasia, published in 1662, that he employed a net of silver wire in the focus of the eye-glass of his telescopes, for measuring the diameters of the planets, the distances of the fixed stars, and for taking an accurate drawing of the lunar spots. He had also a contrivance for turning this net in the focus of the telescope, in order to cause the star to move along one of his wires, and he obtained the angular distance of the wires, by counting the number of seconds which a star required to pass over one of the intervals of his net.

In the year 1666, Messrs. Auzout and Picard, without knowing any thing of the micrometer of Gascoigne, published the description of a micrometer, which consisted of silver wires, or fibres of silk, which were opened and shut by means of a screw.

The micrometer was soon pretty generally introduced among the instruments of an observatory, and underwent great improvements: New forms of it were invented; and by the successive labours of astronomers and opticians, it has been brought to a very high degree of perfection. These various improvements and new forms of the micrometer, will be described under the following nine chapters.

I. On fixed micrometers with an invariable scale.
II. On Wire-micrometers, in which the wires are opened and shut mechanically.
III. On Wire-micrometers, in which the wires are opened and shut optically.
IV. On Double image micrometers, in which the lenses or mirrors are opened and shut mechanically.
V. On Double image micrometers, in which the lenses, or mirrors, or prisms, are opened and shut optically.
VI. On Angular or Position micrometers.
VII. On Lucid disc micrometers.
VIII. On Doubly refracting micrometers.
IX. On Micrometers for microscopes.

Chap. I.—*On Fixed Micrometers with an Invariable Scale.*

The earliest micrometer of this description that appears to have been used by astronomers, was constructed by the celebrated Huygens. In the focus of the eye-glass of his telescope, he fixed a brass plate with a circular aperture a little less than that of the eye-glass. He measured the angle subtended by the diameter of this circle, by measuring the time of a star's passage over it, which he found to be $17\frac{1}{4}$ minutes. He then prepared two or three long and slender brass plates of various breadths, whose sides were very straight, and converged very gradually. In using these plates to measure the diameter of a planet, he slid one of them through two slits in the opposite sides of the tube, so that the plane of the long plates touched the plane of the circular aperture, or field; and he then observed in what part of the plate the breadth of it just covered the whole planet. By taking this breadth between the points of a pair of fine compasses, and by comparing it with the diameter of the aperture, he obtained the apparent diameter of the planet. Sir Isaac Newton has remarked, that the diameters of the planets are always somewhat bigger, when measured in this way, than they ought to be. This error, however, might have been corrected by using long tapering slits in place of plates.

A fixed micrometer, or *reticulum*, for determining the relative places of stars, was invented and used by M. Cassini. It consists of four hairs *a b*, *c d*, *e f*, *g h*, (Plate CCCLXXV. Fig. 1.) crossing one another at right angles in the focus of the eye-glass at the same point *i*, so that the two first are inclined 45° to the two last. The telescope is then directed, so that the preceding star may appear upon the hair *a b*, and is then turned about its axis till the star moves along *a b*. The time of the first star's arrival at the centre *i*, is then noted by a clock, and likewise the time of the subsequent star's arrival at the perpendicular hair *e d*. The interval between these times, converted into degrees and minutes, is the difference of the right ascensions of the two stars. In order to find the difference of their declinations, the times of the subsequent star's arrival at the points *k* and *l* of the oblique hairs *e f*, *g h*, is noted. The half of the interval between these times, is the time in which it describes *l m*, or *m k*, which, converted into degrees and minutes, gives the angular distance *l m*; and this being diminished, in the ratio of the radius to the cosine of the star's declination, gives the value of *m i*, the difference in declination of the two stars.

This reticulum was much improved by our eminent countryman, Dr. Bradley. In order to avoid the inconvenience of turning the telescope about its axis, he placed the ring *a b c*, (Plate CCCLXXV. Fig. 2.) of the reticulum, in a groove cut in the fixed ring ABC, and having confined it laterally by three small plates of brass at A, B, C, he gave it a motion round the axis of the tube by the endless screw DEF, working in a toothed arch *d e* fixed to the moveable ring *a b c*. The hairs *g h*, *i k* cross one another at right angles at *f*, the centre of the rings; and when the telescope is so placed that the range of a star falls upon *f*, let us suppose it to move in any line *f g*; then, by turning the nut D, and consequently the hair *f d* about the fixed point *f*, till it touches the star at *q*, it will then coincide with the direction of the star's motion, and then all other stars will move parallel to it. In order to find the difference of declination of two stars, he observes the times of their arrival at the edges of two slender brass bars *g i o*, *g k p* fixed to the ring *a b c*, and equally inclined to its diameter *g h*, at an angle of 26° 34′, when *f k* and *f i* will be each one half of *f g*, and *k i* = *f i*. Hence the difference of *i k* and *l n* will be equal to *f m*, the difference of their heights: that is, the difference of the times of the transits of the stars over any two bars *i k* and *l n* will be the difference of their declination as already explained.

A very simple and useful micrometer, invented by M. Cavallo, is represented in Plate CCCLXXV. Fig. 3. It consists of a thin and narrow slip of mother-of-pearl, finely divided into 200dth parts of an inch, by lines which reach from one edge to near the middle of the scale. It is about the 24th part of an inch broad, and its thickness is equal to that of common writing paper. The simplest way of fixing it, is to stick it by strong cement, on the diaphragm or field-bar, placed in the focus of the eye-glass next the eye. The micrometer which M. Cavallo adapted to a three feet achromatic telescope, magnifying about 84 times, had each of its divisions nearly equal to a minute, and as $\frac{1}{8}$th part of a division could be estimated by the eye, it was capable of measuring angles within $7\frac{1}{2}$ seconds of a degree. M. Cavallo determines the value of the divisions, by observing the space which any number of divisions subtends at a measurable distance, and computing trigonometrically the angle subtended by that space. It is preferable, however, in all cases, to ascertain the angular extent of the field of view by the time of the passage of an equatorial star, and to observe the number of divisions of the micrometer which correspond to that angle.

"This simple micrometer," says Dr. Brewster, "is very convenient in portable telescopes, where the eye-piece has a motion about its axis; but in telescopes supported upon stands, where the eye-piece is moved by a rack and pinion, the slip of mother-of-pearl cannot turn round upon its axis, and, consequently, can only measure angles in one direction. This difficulty, indeed, might be surmounted by a mechanical contrivance for turning the diaphragm about its centre, or, more simply, by giving a motion of rotation to the tube which contains the first and second eye-glasses. As such a change in the eye-piece, however, is often inconvenient and difficult to be made, Mr. Cavallo's micrometer has this great disadvantage, that it cannot be used in reflecting telescopes, or in any achromatic telescope where the adjustment of the eye-piece is effected by rack-work, unless the structure of these instruments is altered for the purpose. Another disadvantage of this micrometer arises from the slip of mother-of-pearl passing through the centre of the field. The picture in the focus of the eye-glass is broken into two parts, and the view is rendered still more unpleasant by the inequality of the segments into which the field is divided. In addition to these disadvantages, the different divisions of the micrometer are at unequal distances from the eye-glass which views them, and therefore can neither appear equally distinct, nor subtend equal angles at the eye."

In order to remedy these inconveniences, Dr. Brewster was led, in 1805, to contrive the circular mother-of-pearl micrometer, which is free of all these disadvantages, and has likewise the benefit of a kind of diagonal scale, increasing in accuracy with the angle to be measured. This micrometer, which he has often used, both in determining small angles in the heavens, and such as are subtended by terrestrial objects, is represented in Plate CCCLXXV. Fig. 4. which exhibits its appearance in the focus of the first eye-glass. The black ring, which forms part of the figure, is the diaphragm, and the remaining part is an annular portion of mother-of-pearl, having its interior circumference divided into 360 equal parts. The mother-of-pearl ring, which appears connected with the diaphragm, is completely separate from it, and is fixed at the end of a brass tube, which is made to move between the third eye-glass and the diaphragm, so that the divided circumference may be placed exactly in the focus of the glass next the eye. When the micrometer is thus fitted into the telescope, the angle subtended by the whole field of view, or by the diameter of the innermost circle of the micrometer, must be determined either by measuring a base, or by the passage of an equatorial star; and the angles subtended by any number of divisions or degrees will be found by a table constructed in the following manner.

Let A $m\,p\,n\,b$, Plate CCCLXXV. Fig. 5. be the interior circumference of the micrometer scale, and let $m\,n$ be the object to be measured. Bisect the arch $m\,n$ in p, and draw C m, C p, C n. The line C p will be at right angles to $m\,n$, and therefore $m\,n$ will be twice the sine of half the arch $m\,p\,n$. Consequently. A B : $m\,n$ = Rad : Sine of $\frac{1}{2}\,m\,p\,n$; therefore $m\,n \times$ R = sin. $\frac{1}{2}\,m\,p\,n \times$ AB, and $m\,p\,n = \frac{\sin\frac{1}{2}\,m\,p\,n}{R} \times$ AB; a formula by which the angle subtended by the chord of any number of degrees may be easily found. The first part of the formula, viz. $\frac{\sin.\frac{1}{2}\,m\,p\,n}{R}$, is constant, while AB varies with the size of the micrometer, and with the magnifying power which is applied. Dr. B. therefore computed the following Table, containing the value of the constant part of the formula for every degree or division of the scale.

Degrees.	Constant part of the Formula	Degrees.	Constant part.	Degrees.	Constant part.	Degrees.	Constant part.
1	.0087	46	.3907	91	.7133	136	.9272
2	.0174	47	.3987	92	.7193	137	.9304
3	.0262	48	.4067	93	.7254	138	.9336
4	.0349	49	.4147	94	.7314	139	.9367
5	.0436	50	.4226	95	.7373	140	.9397
6	.0523	51	.4305	96	.7431	141	.9426
7	.0610	52	.4384	97	.7490	142	.9455
8	.0698	53	.4462	98	.7547	143	.9483
9	.0785	54	.4540	99	.7604	144	.9511
10	.0872	55	.4617	100	.7660	145	.9537
11	.0958	56	.4695	101	.7716	146	.9563
12	.1045	57	.4771	102	.7771	147	.9588
13	.1132	58	.4848	103	.7826	148	.9613
14	.1219	59	.4924	104	.7880	149	.9636
15	.1305	60	.5000	105	.7934	150	.9659
16	.1392	61	.5075	105	.7986	151	.9681
17	.1478	62	.5150	107	.8039	152	.9703
18	.1564	63	.5225	108	.8090	153	.9724
19	.1650	64	.5299	109	.8141	154	.9744
20	.1786	65	.5373	110	.8192	155	.9763
21	.1822	66	.5446	111	.8241	156	.9781
22	.1908	67	.5519	112	.8290	157	.9799
23	.1994	68	.5592	113	.8339	158	.9816
24	.2079	69	.5664	114	.8387	159	.9833
25	.2164	70	.5735	115	.8434	160	.9848
26	.2250	71	.5807	116	.8480	161	.9863
27	.2334	72	.5878	117	.8526	162	.9877
28	.2419	73	.5948	118	.8572	163	.9890
29	.2504	74	.6018	119	.8616	164	.9903
30	.2588	75	.6088	120	.8660	165	.9914
31	.2672	76	.6157	121	.8704	166	.9925
32	.2756	77	.6225	122	.8746	167	.9936
33	.2840	78	.6293	123	.8788	168	.9945
34	.2923	79	.6361	124	.8829	169	.9954
35	.3007	80	.6428	125	.8870	170	.9962
36	.3090	81	.6494	126	.8910	171	.9969
37	.3173	82	.6561	127	.8949	172	.9976
38	.3256	83	.6626	128	.8988	173	.9981
39	.3338	84	.6691	129	.9026	174	.9986
40	.3420	85	.6756	130	.9063	175	.9990
41	.3502	86	.6820	131	.9100	176	.9994
42	.3584	87	.6884	132	.9135	177	.9996
43	.3665	88	.6947	133	.9171	178	.9998
44	.3746	89	.7009	134	.9205	179	1.0000
45	.3827	90	.7071	135	.9239	180	1.0000

A series of micrometers, principally for the purposes of microscopical observations, were constructed by the late Mr. Coventry of Southwark, with a degree of delicacy and accuracy which was never before equalled. They consisted of glass, ivory, and silver scales, on which are drawn parallel lines from the 10th to the 10,000dth part of an inch.

Mr. Barton of the mint, well known for his mechanical ingenuity, has carried the art of dividing micrometrical scales to the highest degree of perfection. The engine which he uses was given to him by his late father-in-law, the celebrated Mr. Harrison. It was constructed by Mr. Harrison himself, and its merits depend chiefly on the beauty and excellence of the screw; the apparatus for cutting which by an excellent inclined plane, also accompanied the engine The plate in the screw is not divided higher than 2000dth parts of an inch; but Mr Barton has drawn divisions on glass, so minute as the 10,000dth part of an inch. In drawing lines of 2000 in an inch, Mr. Barton often leaves out *one line* by design; and one of the greatest proofs of the stability of the engine is, that after having taken off the brass table with the work upon it, when the omission is distinctly perceived, *he can restore it to its place, and introduce the line without its being distinguishable from the rest.*

For farther information on fixed micrometers, see Huygen's *Systema Saturni*, p. 82. Cassini, *Phil. Trans.* No. 236. Smith's *Optics*, vol. ii p. 342 Cavallo, *Phil. Trans.* 1791, p. 283. Cavallo's *Nat. Philosophy*, vol. iii *Phil. Mag.* vol. xxix p. 28. Brewster's *Treatise on New Philosophical Instruments*. p. 48. Bernoulli, *Mem. Acad. Berl.* 1773, p. 193. Watt, in the *Edinburgh Philosophical Journal*, vol. ii. p. 121.

CHAP. II.

On Wire Micrometers, in which the Wires or Fibres are opened and shut mechanically.

In the original micrometer of Mr. Gascoigne, two metallic edges were made to separate from and approach one another; and when his instrument was shown to Dr. Hooke, he immediately suggested the substitution of fine wires in place of the edges of metallic plates, and they have accordingly been retained in almost all the subsequent forms of the instrument.

The wire micrometer, as constructed by Messrs. Auzout and Picard, underwent various improvements in the hands of Dr. Bradley and other astronomers, and in our article Astronomy, we have given a drawing and description of one of the most improved kind, as made by Mr. Troughton.

In all micrometers with moveable fibres, their separation and approach is effected by means of a screw with about 100 threads in an inch, and as every revolution of the screw is again divided upon a circular plate into 100dths of an inch, the 10,000dth part of an inch may be perceived in the number of the wires. Sometimes the screws are made with 200 or even 300 threads in an inch, with the view of giving additional delicacy to the scale, but in cases of this kind the threads are so minute, that they have not the requisite strength for a micrometer.

The double screw of Mr. Hunter, which we have already described in our article Mechanics, furnishes us with the means of obtaining a very slow motion in the moveable wires by means of two screws, with different numbers of threads in an inch, the effect being the same as if a single screw was employed, having the size of its threads equal to the difference of the size of the threads of the two screws.

The very same contrivance, with a slight modification, has been proposed by M. Prony, under the name of the *nonius screw*, for the purpose of moving the wires of micrometers. It is represented in Plate CCCLXXV. Fig. 6. where AB is an axis divided into three parts, *ab*, *cd*, *ef*. The screws upon the parts *ab*, *ef* have the same number of threads in an inch, and pass through two female screws in the fixed supports C, D. The axle AB moves horizontally, and any part of its axis describes at each turn of the handle H, a space equal to the distance between the threads. The middle screw *cd* has a greater or lesser number of threads in an inch than *ab* or *ef*, the difference between the two being as small as we chuse. It passes through a female screw M, which carries the moveable micrometer wire, and the piece M is prevented from turning by a groove in CD, in which its lower extremity is guided. The screw M therefore will be carried backwards towards H by the screw *cd* more or less rapidly than it advances forwards along with the axis AB, according as the number of threads in *cd* is less or greater than those in *ab* and *ef*. The threads in the screws *ab*, *ef*, may be of any magnitude, as the piece M advances or recedes in virtue of their difference. It is found difficult in practice to make the two screws *ab*, *ef*, so equal that they experience no resistance in the parts C, D; but one of the two may be suppressed, if supplied by a simple axis, which is in fact reducing it exactly to Mr Hunter's screw.

The fibres for micrometers have generally been silver wires drawn to a great degree of fineness. Muschenbroek informs us, that an artist of Nuremberg drew gold wire so fine, that 500 inches of it only weighed one grain; but he does not state by what means it was made. In 1775, Felix Fontana recommended the spider's web as a substitute for silver wire, and he is said (though we suspect an error in the statement) to have found them so small as the 8000th part of a line. The use of the spider's web was introduced by Mr. Troughton, who found it to be so fine, opaque, and elastic, as to answer all the objects of practical astronomy. He has found, however, that it is only the *stretcher*, or the long line that supports the web, which possesses these valuable properties. The facility with which fine glass fibres can at all times be obtained induced Dr. Brewster to recommend them for micrometrical fibres, and some of those which he employed were about $\frac{1}{1300}$ of an inch in diameter, bisected longitudinally with a fine transparent line about the 3000dth of an inch in diameter. Dr. Brewster sometimes employed threads of melted sealing wax. Mr. Wallace has more recently recommended the fibres of asbestos, which can be obtained to any degree of fineness.

The formation of micrometrical fibres has, however, been brought to a high degree of perfection by Dr. Wollaston, who has discovered a method of making them of any degree of fineness. Along the axis of a cylindrical mould he placed a small platinum wire, and then filled the mould with melted silver. The silver was now drawn out till it was about the 300dth part of an inch, for example, in diameter, and it is manifest, that if the platinum wire was $\frac{1}{10}$th of the diameter of the silver wire, before the operation of drawing commenced, it must be $\frac{1}{3000}$dth of an inch in diameter when the silver wire is $\frac{1}{300}$dth. In this state the silver wire, with the platinum one inclosed, is bent into the form of the letter U, making a hook at each of its ends, and in this state it is suspended by a gold wire and dipped in hot nitric acid or aquafortis. The silver is now dissolved by the nitric acid, except at its extremities, and the platinum wire remains untouched by the acid. The hooks at the end of the wire retaining the silver served to make the platinum wire visible. By this ingenious method he easily obtained platinum wires, or gold wires of $\frac{1}{3000}$ or $\frac{1}{5000}$ an inch in diameter, and, with a little attention, he formed them so small as the $\frac{1}{18000}$th part of an inch. The single lens micrometer by which Dr. Wollaston measured the diameter of these fibres, will be described in Chapter IX.

Micrometrical fibres may be placed in delicate parallel grooves formed on the diaphragm of the first eye-glass, and fixed in their places, for temporary purposes, by a thin layer of bees-wax or a drop of varnish; but when they are required to be kept at an invariable distance, it is safer to pinch them to the diaphragm by a small screw nail near the extremity of each wire. In order that the fibres may be placed exactly in the anterior focus of the eye-glass, the diaphragm should be made moveable along the axis of the eye-tube.

See Townley, *Phil. Trans.* No. 25. Hooke, *Phil. Trans. Abr.* vol. i. p. 217. Hooke's *Posthumous Works*, p. 497, 498. Bevis's *Account of Gascoigne's Observations, in Phil. Trans.* vol. xlviii. p. 190. Auzout and Picard, *Mem. Acad. Par.* See Rozier. Bradley in Smith's *Optics*, vol. ii. p. 345, 346. Fontana, *Saggio del real gabinetto di Fisica e di storia naturale de Firenze*, Rom. 1775. Prony in Lanz and Bettancourt's *Essais sur la Comp. de Machines*, p. 15. Brewster's *Treatise on New. Phil. Instruments*, p. 74. Wollaston, *Phil. Trans.* 1813, Part I. *Edinburgh Philosophical Journal*, vol. i. p. 202.

CHAP. III.

On Wire Micrometers, in which the scale is varied, or the Wires opened and shut optically.

The idea of varying the magnitude of the meshes of a net of silver wire, permanently fixed in the focus of the eye-glass of a telescope, for the purpose of measuring the digits of eclipses, seems to have been first suggested by M. de La Hire. The same idea afterwards occurred to the late celebrated Mr. Watt, (as he himself informed us,) who constructed a sort of micrometer upon this principle; but he never published any account of it, and did not examine its optical properties. See *Edinburgh Philosophical Journal*, vol. ii. p. 124.

The idea of opening and shutting one or more pairs of wires optically, instead of mechanically, was first applied as a general principle for micrometers by Dr. Brewster. In his treatise on *New Philosophical Instruments*, he has described various micrometers of this kind, which seem to possess properties worthy of the attention of practical astronomers; and, if we are not misinformed, one of these telescopical micrometers has been recently fitted up for use in the Observatory at Greenwich, at the desire of our celebrated astronomer royal, Mr. Pond.

"The diameter of the sun, or any portion of space, may be comprehended between a pair of fixed wires placed in the eye-piece of a telescope, either by a mechanical or an optical contrivance; in the one case, by varying the distance of the wires till they contain exactly the solar disc; and in the other, by expanding or contracting the image of the sun till it exactly fills the space between a pair of fixed wires. Thus let S′s′, Plate CCCLXXV. Fig. 7. be the sun in contact with the lower wire CD, the wire AB may be moved into the position *ab*, so as to touch the upper limb S′ of the sun; or if the wires AB, CD, are both fixed, we may, by increasing the magnifying power of the telescope, expand the image S′s′ into Ss, till its north and south limbs are in accurate contact with the fixed wires. In the first of these methods, which has been already explained in the description of the common wire micrometer, the angle subtended by the sun is measured by the revolutions of the screw, which are necessary to bring the wire AB from a state of coincidence with CD in the position *ab*:—In the second method, which is the principle on which the new instrument is founded, the angle is measured by the change of magnifying power which is required to enlarge the solar image, till its diameter is exactly equal to the distance between the wires. Though the wires are in this case absolutely fixed, yet the angle which they subtend at the observer's eye continually changes with the magnifying power of the telescope; for if the sun S′s′ fills half the space between the wires AB, CD, before the magnifying power is increased, the angle subtended by these wires must be equal to twice the diameter of the sun, or about 62 minutes; and when the solar image has been expanded to Ss, the wires AB, CD, only subtend an angle equal to the sun's diameter, or about 31 minutes; so that if this expansion of the sun's image has been produced by a gradual change in the magnifying power of the telescope, the wires must have subtended every possible angle between 31 and 62 minutes.

The gradual variation of the magnifying power, which is thus essential to the construction of the instrument, may be effected by different contrivances,—by changing the distance between the two parts of the achromatic eye-piece; by separating one or more of the lenses of the compound object glass; or by making a convex, a concave, or a meniscus lens, move along the axis the telescope, between the object glass and its principal focus.

The last of these contrivances, which is, for many reasons, preferable to any of the other two, is represented in Plate CCCLXXV. Fig. 8. where O is the object glass, whose principal focus is at *f*, and L the separate lens, which is moveable between O and *f*. The parallel rays R, R, converging to *f*, after refraction by the object glass O, are intercepted by the lens L, and made to converge to a point F, where they form an image of the object from which they proceed. The focal distance of the object glass O has therefore been diminished by the interposition of the lens L, and consequently the magnifying power of the telescope, and the angle subtended by a pair of fixed wires in the eye-piece, have suffered a corresponding change. When the lens is at *l*, in contact with the object glass, the focus of parallel rays will be about ϕ; the magnifying power will be the least possible, and the angle of the wires will be a *maximum;* and when the lens is at *l′*, so that its distance from O is equal to O*f*, the focus of parallel rays will be at *f*;—the magnifying power will be the greatest possible, and the angle of the wires will be a *minimum.* When the lens L has any intermediate position between l and l', the magnifying power and the angle of the wires have an intermediate value, which depends upon the distance of the lens from the object glass. Hence it appears, that the scale which measures these variations in the angle of the wires, may always be equal to the focal length of the object glass; and it may be shewn in the following manner, that it is a scale of equal parts, the changes upon the angle being always proportional to the variation in the position of the moveable lens.

The point f being that to which the rays incident upon L always converge, we shall have, by the principles of optics, $F+Lf:F=Lf:LF$, F being equal to the focal length of the lens L. Now it is obvious, that the magnitude of the image formed at F, after refraction through both the lenses, will be to the magnitude of the image formed at f by the object glass O, (or by both lenses when L is at l',) as LF is to Lf; for the image formed at f is the virtual object from which the image at F is formed, and the magnitude of the image is always to the magnitude of the object directly as their respective distances from the lens. Hence the magnifying power of the telescope, when the lens L is in these two positions, is in the ratio of LF to Lf, consequently the angle subtended by the wires, which must always be inversely as the magnifying power, will be as Lf to LF.

By making $Lf=b$, the preceding formula becomes $F+b:F=b:LF$. Hence $LF=\frac{Fb}{F+b}$. Then calling A the least angle subtended by the wires, or the angle which they subtend when the lens L is at l', and α the angle which they subtend when the lens is at L or in any other position, we have $A:\alpha=LF:Lf$, that is $A:\alpha=\frac{Fb}{F+b}:b$, and $\alpha=A+\frac{Ab}{F}$=the angle for any distance b. Calling P the greatest magnifying power, and π the magnifying power for any distance b, we shall have $P:\pi=b:\frac{Fb}{F+b}$, and $\pi=\frac{PF}{F+b}$= the power for any distance b. Making $A=20$, $P=20$, $F=10$, and $b=0$, 1, 2, 3, 4, successively, we obtain from these two formulæ the results in the following table.

Different values of b	Calculated magnifying powers.	Differences.	Calculated angles.	Differences.
0	20.00000		20′	
		1.81818		2
1	18.18182		22	
		1.51515		2
2	16.66666		24	
		1.28205		2
3	15.38461		26	
		1.09890		2
4	14.28571		28	

Hence it appears, that when the different values of b are in arithmetical progression, the angle α of the wires varies at the same rate, and therefore the scale which measures these angular variations is a scale of equal parts. The magnifying power, however, does not vary with equal differences, and consequently a scale for measuring its variations, if any scale were wanted, is not a scale of equal parts.

Having thus ascertained the nature of the scale, we shall now proceed to point out the method of constructing it. It is obvious that the length of the scale is arbitrary, and may be made equal either to the whole focal length Of of the object glass, or to any portion of it. If the lens L moves along the *whole* length of the axis Of, the angle subtended by the wires can be varied to a greater degree than if the lens moves only along a portion of the axis; but as this advantage may be obtained by a contrivance hereafter to be described, it will be found more convenient for astronomical purposes to make the lens moveable only along a part of the axis, as from L towards f.

Let us suppose, therefore, that when the object glass O is 36 inches in focal length, 10 inches will be a convenient length for the scale, and that the telescope is constructed so that the lens L can move freely through that space reckoned from f, the next thing to be determined is the focal length of the lens L. It is evident that a lens of 6 inches focal length will produce a much greater diminution of magnifying power, and consequently a much greater increase upon the angle of the wires in moving from f to L than a lens of greater focal length; so that the value of the whole scale in minutes or seconds, or the increase in the angle occasioned by the motion of the lens from f to L, must be inversely as the focal length of the moveable lens. If the angle of the wires is 26 minutes, for example, and if the magnifying power of the telescope is diminished from 40 to 30 by the motion of the lens from f to L; then when the lens is at L, the angle of the wires will be 34′ 40″, for 30 : 40=26′ : 34′ 40″. Hence we have a scale of 10 inches to measure 26′—34′ 40″, or 8′ 40″, and therefore every tenth of an inch on the scale will be equal to 5″.2.

If we employ a lens of much greater focal length, so as to diminish the magnifying power only from 40 to 35, and if the angle of the wires is 29 minutes; then when the lens is at L, the angle of the wires will be 33′ 9″ nearly, for 35 : 40=29′ : 33′ 9″. And hence we have a scale of 10 inches to measure 29′—33′ 9″, or 4′ 9″, consequently every tenth of an inch on the scale corresponds to 3″.3. From this it will be manifest, that the accuracy of the scale is increased by increasing the focal length of the moveable lens.

The two preceding examples are suited to a micrometer for measuring the diamaters of the sun and moon at their various distances from the earth; but, in order to show the resources of the principle on which the instrument is founded, we shall take another example, better adapted to this purpose.

Let us suppose that the pair of fixed wires subtends only an angle of 40″, for the purpose of measuring the distance between double stars, or the diameters of some of the smaller planets, that the telescope magnifies 300 times, and that the lens L in its motion from f to L, through a space of 10 inches, diminishes the power of the instrument to 240; then when the lens is at L, the angle of the wires will be 50″, for 240 : 300 = 40″ : 50″. Hence we have a scale of ten inches to measure 40″—50″, or 10″, so that every inch of the scale corresponds to 1″, and every tenth of an inch to 6‴.) From this it follows, that the accuracy of the scale increases as the angle subtended by the fixed wires diminishes.

If it should be found convenient to make each division of the scale correspond to a greater variation in the angle than in any of the examples which we have given, it would then be proper to make use of a vernier for subdividing the units of the scale.

In order to show more clearly the method of completing the scale, we have represented a telescope furnished with a micrometer, in Plate CCCLXXV. Fig. 9, where AB is the principal tube, with the object glass at B; CD a secondary tube, at the right hand extremity of which is fixed the lens L, (Fig. 8.) which is moved backwards and forwards with the tube, by the milled head F; and E the eye-piece, which is adjusted to distinct vision by the milled head G. The small index i projecting from the principal tube below A, and furnished with a vernier scale if necessary, points out the divisions on the scale. Let it now be required to construct the scale for the 2d Example, where the lens L, by moving from f to L, changes the power of the telescope from 40 to 35. Having moved the tube CD as far out as possible, by the milled head F, mark the point of it at n to which the index i points, and this will be the beginning or zero of the scale. Adjust the eye-tube E to distinct vision, and find by experiment* the angle subtended by the fixed wires: Let this angle be 29 minutes. Move the tube CD as far in as possible by means of the nut F, till the index i points to m, and mark this as the other extremity of the scale. Let the eye-tube E be again adjusted to distinct vision, and the angle subtended by the wires again determined experimentally; and let this angle be now 33′ 9″. In order to find the point of the scale corresponding to 33′, say, As 4′ 9″, the value of the whole scale is to 10 inches, the length of the scale, so is 9″ to 36 hundredths of an inch, which, being set from m to o, will mark out the point o as corresponding to 33′. The space $o\,n$ being divided into four parts for minutes, and each minute into as many divisions as possible, the micrometer will be ready for use. If great accuracy is required, every unit of the scale might be determined experimentally, by any of the methods mentioned in the preceding note. The instrument thus constructed, is capable of measuring angles only between 29′ and 33′ 9″, and is therefore peculiarly fitted for determining the diameters of the sun and moon. Its range, however, could easily have been extended, by lengthening the tube CD, or by employing a moveable lens, of smaller focal length;—or instead of one pair of wires, we might use several pairs, as AB, CD, $a\,b$, $c\,d$, $\alpha\beta$, $\gamma\delta$, (Plate CCCLXXV. Fig. 10.) so placed that only one pair should be in the field of view at a time, and that the least angle of the second pair should be equal to the greatest angle of the first pair, and the least angle of the third pair equal to the greatest angle of the second.

When the micrometer is constructed on these principles, it is certainly free from almost all those sources of error with which the wire micrometer is affected. The imperfections of the screw, the errors arising from the uncertainty of the zero, from the bad centering of the lenses, from the want of parallelism in the wires, and from the minuteness of the scale, are completely removed. Nay, if the scale is formed by direct experiments, whatever errors may exist in the instrument are actually corrected; for as the sources from which these errors proceed existed in the instrument during the formation of the scale, they cannot possibly affect the result of any observation. The scale is in fact the record of a series of experimental results, and the observation must be as free from error as the experiments by which the scale was formed. It would, therefore, be of great advantage, in micrometrical observations, to make the points B, C, (Plate CCCLXXV. Fig. 11,) with which the wires appear to come in contact, as luminous as the objects to which it is intended to apply the instrument, or rather to have a series of results for objects of various degrees of illumination.

In the preceding micrometer, the angle of a pair of fixed wires is increased and diminished by the motion of a second object-glass along the axis of the telescope; while, in the present instrument, the variation of the angle is effected by separating the two parts which compose an achromatic eye-piece; or, when the eye-piece consists of two or three lenses, by separating the lens next the eye from the remaining lenses.† If the small tube, which contains the field-glass and the first eye-glass, be pulled out beyond its natural position, the magnifying power of the instrument will be increased; and if the same tube be pushed farther in than its natural position, the magnifying power will be diminished. It will be found, in general, that if the tube already mentioned be allowed to move over the space of four inches, that is, about two inches on each side of its natural position, the magnifying power at one extremity of this space will not be very far from double of what it is at the other extremity.

* In order to find the angle subtended by a pair of wires AB, CD, Fig. 7, direct the telescope, the object-glass of which is supposed to be at the point A, Fig. 11, to any upright object MN, with a plain surface, perpendicular to the axis of the telescope, and placed at a convenient distance, 500 feet for example, and observe the space which the wires appear to occupy, or the points B, C, which the wires seem to cover, taking particular care that the line joining these points is perpendicular to the wires. Let the space BC be 4 feet 2.57 inches. Bisect BC in D, and draw DA; then, in the right angled triangle ADB, we have AD=500 feet, and BD=2 feet 1.285 inches, to determine the angle BAD, which, by the simplest case of plain trigonometry, will be found to be 14′ 30″, so that the whole angle BAC, or that subtended by the wires, will be 29′.

It is obvious, however, that on account of the proximity of the object MN, the image of it in the telescope is formed by rays which fall diverging upon the object glass O, and therefore this image will be formed at f', Fig. 8, at a greater distance than the principal focus f. Hence the magnifying power will be greater, and the angle of the wires less, than they would have been had the object MN been infinitely distant. It is necessary, therefore, to find the corrected angle BAC, so that we may have the real value of that angle when the telescope is directed to the heavenly bodies. Let O f, the focal length of O, Fig. 8, be called φ; D the distance of the object MN; a the angle found by experiment; x the correct angle; F the focal length of L; and b the distance of the lens L from the focus f. Then we have, by the principles of Optics, $\frac{\varphi^2}{D-\varphi}=ff$, the increase of focal length. Calling this value of ff' m, we have $b+m=Lf'$, and by the principles of Optics, $F+b+m : F=b+m : \frac{Fb+Fm}{F+b+m}$ for the new value of LF, or for LF′. Hence LF : LF′$=a:x$; that is, $\frac{Fb}{F+b} : \frac{Fb+Fm}{F+b+m}=a:x$; a formula from which the corrected angle x may be readily found.

† An instrument of nearly the same kind with the following, has been described by Mr. Ezekiel Walker, in the *Phil. Mag.* Aug. 1811, Vol. xxxviii. p. 127, as an invention of his own. So early as the end of the year 1805, I sent a drawing and description of the eye-piece micrometer to Mr. Carey, optical instrument maker, London. In 1806, one of the instruments made for me by Messrs. Miller and Adie, Edinburgh, was examined by Professor Playfair; and since that time it has been in the possession of a friend in London.

The eye-piece micrometer is represented in Plate CCCLXXV. Fig. 12. with all the lenses in their natural position. The part AFG, containing the two lenses A, C, is fixed to the telescope, and a space is left between the tube AC and the outer tube, in order to permit the moveable part of the eye-piece to get sufficiently near to the lens C, and also to a sufficient distance from it. The other tube DB, containing the field-glass D, and the first eye-glass B, is moved out and in by a rack and pinion E. The scale is engraven upon the upper surface $l\,n$, and the divisions are pointed out by the index of a vernier placed at the extremity m of the outer tube FG. The zero of the scale is the point marked out by the index of the vernier, when the tube DB is pushed in as far as possible; and the divisions may be read off, if necessary, by means of a convex glass at F, fixed to the tube AFG.

The value of the scale of this micrometer may be determined by direct experiment, by the methods which have already been described.

The following method, however, is more simple, and perhaps equally accurate. After having found the greatest angle subtended by a pair of wires, placed in the focus of the eye-glass, or the angle when the index is at the zero of the scale, by the method in p. 224, note, take the eye-piece out of the telescope, and having pushed the tube which contains the moveable lens or lenses as far in as possible, direct it as a microscope to a scale minutely divided.* Mark the position of the index when the wires comprehend exactly a certain number of these divisions, say 50, which they may be made to do, by a very trifling motion of the moveable tube, and make this point the zero of the scale. Let the moveable tube be now pulled out till the wires successively comprehend 48, 46, 44, 42, &c. of the divisions, or any other numbers, diminishing in arithmetical progression, and mark these points upon the tube. By this means, a scale will be formed, in which the divisions correspond to equal variations in the angle. If it should be found convenient to divide the scale into equal parts, the value of the divisions may be found in the same way.

In applying to the reflecting telescopes of Gregory and Cassegrain the principle which has been already explained, we are led to the formation of a micrometer, remarkable for the simplicity of its construction; and what, at first sight, may appear paradoxical, *we may convert a Gregorian or a Cassegrainian telescope into a very accurate micrometer, almost without the aid of any additional apparatus.*

It will be readily seen, by those who understand the theory of these telescopes, that their magnifying power may be increased merely by varying the distance between the eye-piece and the great speculum; and then producing a distinct vision by a new adjustment of the small mirror. Hence a pair of wires fixed in the eye-piece may be made to subtend different angles, solely by having that part of the instrument moveable along a portion of the common axis of the two mirrors.

In order to understand this, let SS, (Plate CCCLXXV. Fig. 13) be the great speculum of a Gregorian telescope, having a round hole in its centre, and placed at the extremity of the tube AA; and let M be the small speculum, whose focus is G, and centre H, attached to an arm MQ, and moveable along the axis of the instrument by means of a screw and milled head. The rays RR, proceeding from the lower part of any object, and falling upon the speculum SS, will be reflected to R′, and will there form an image of that part of the object. In like manner, the rays $r\,r$ will form an image of the upper part of the object at r'. The rays diverging from the image R′ r', and intercepted by the small speculum M, will form another image R″ r'', at the distance MF; which being viewed by the eye-glass at E, whose focal distance is FE, will appear distinct and magnified to the observer.

Let us now suppose that the lens E, or the eye-piece of the telescope, (which is generally a Huygenian eye-piece, with two glasses,) is moved by a suitable apparatus into the position E′, and that a point F′ is taken, so that F′ E′ may be equal to FE. Then it is manifest, that, in order to have a distinct view of the object in this new position of the eye-piece, the image formed by the small speculum must be brought to F′ in the focus of the lens E′. But as the place of the first image R′ r' is in no respects changed by the change of position in the eye-piece, the formation of the image at F can be effected only by bringing the small mirror M into a position M′, nearer the image R′ r' than it was before; and as the space MM′ through which it has been moved, in order to converge the rays to F′, must necessarily be less than FF′ = EE′, the space through which the eye-glass has moved; the distance M′ F′ of the new image at F′ from the small mirror must be greater than MF, the distance of the other image at F, in the ratio of M′ F′ to MF; and the magnifying power of the instrument must at the same time be increased, and the angle subtended by the wires diminished.

In the formation of this micrometer, we may either construct the scale from calculation, after the two extreme points of it have been fixed experimentally, by the method already described; or all the points of the scale may be determined by direct experiment. It would perhaps be more convenient to divide the scale into equal parts, and to construct a table from experiment, for the purpose of shewing, by inspection, the angle which corresponds to any number of these equal divisions."

CHAP. IV.

On Double Image Micrometers, in which the Lenses, Mirrors, and Prisms, are opened and shut mechanically.

The first hint of a double image micrometer seems to have been communicated, in 1675, by the celebrated Danish astronomer M. Roemer. It appears, however, to have remained so entirely unnoticed, that it was not even known to Mr. Servington Savary of Exeter, in the year 1743, when he communicated to the Royal Society of London an account of a double image micrometer, consisting of two lenses, capable of being separated from and of being brought near to one another by mechanical means. When the two images of the sun, or of any other body, were in contact, the distance of the lenses becomes a measure of the angular magnitude of the sun, the value of the scale having been previously

* The beautiful micrometrical scales formerly constructed by Mr. Coventry, and now by Mr. Barton, are admirably adapted for this purpose.

determined by experiment. The account of Savary's micrometer was extracted from the minutes of the Society by Mr. Short, and published in the *Phil. Trans.* for 1753. In 1748, M. Bouguer proposed a similar instrument which he called a heliometer; and in 1753, Mr. Dollond made a farther improvement on this kind of micrometer, by substituting in place of two object-glasses a single object-glass cut in two. As a drawing and description of Mr. J. Dollond's divided object-glass micrometer has already been given in our article Astronomy, and in Plate XLVIII. Fig. 4 and 5, it is unnecessary to enlarge the present article by any description of the more imperfect instruments of Savary and Bouguer. We shall content ourselves with explaining the general principle of all instruments of this kind.

Let the two semi-lenses have their centres at E and H, (Plate CCCLXXV. Fig. 14.) and their principal focus at F, and let P, Q, be two distinct objects, or the opposite limits of the same object, lying in FE, FH prolonged. The images of the two objects P, Q, formed by each semilens, will coincide at F, and therefore two images of the circular object PBQD, viz. $m\,z$ F, $p\,x$ F, will be found touching one another at F. Hence the angular measure of PQ will be equal to the angle which EH or the distance of the centres of the semi-lenses forms at F, and, as the angles measured are very small, they will always vary as EH. The angle, therefore, which corresponds to any one distance of the centres E, H, being known by the methods already described, the angle corresponding to any other distance will be obtained by simple proportion. Mr. Dollond first adapted his micrometer to the object end of a reflecting telescope; but his son afterwards applied it to achromatic telescopes.

The divided object-glass micrometer has a great superiority over the wire micrometer, in so far as it enables us to measure any diameter of the sun or moon, whatever be its inclination to the direction of their motion; whereas, in the wire micrometer, we can only measure that diameter which is perpendicular to the direction of the motion.

In order to apply the divided object-glass micrometer to determine differences of right ascension and declination, Dr. Maskelyne has pointed out the following method.

"Let H C R c, Plate CCCLXXV. Fig. 15, be the field of view, HR and C c two wires bisecting the field of view at right angles to one another, and having a motion in their own plane, turn the wires till the westernmost star (which is the best, have further to move) run along ROH; then separate the two segments, and turn about the micrometer till the two images of the same star lie in the wire C c; and then, partly by separating the segments, and partly by raising or depressing the telescope, bring the two innermost images of the two stars to appear and run along ROH, as a, b, and the vernier will give the difference of their declinations; because, as the two images of one of the stars coincided with C c, the image of each star was brought perpendicularly upon HR or to HR in their proper meridian. And, for the same reason, the difference of their times of passing the wire CO c will give their difference of right ascensions. These operations will be facilitated, if the telescope be mounted on a polar axis. If two other wires KL, MN, parallel to C c, be placed near H and R, the observation may be made on two stars, whose difference of meridians is nearly equal to HR, the diameter of the field of view, by bringing the two images of one of the stars to coincide with one of these wires. If two stars be observed, whose difference of declinations is well settled, the scale of the micrometer will be known.

It has hitherto been supposed, that the images of the two stars can be both brought into the field of view at once upon the wire HOR; but if they cannot, set the micrometer to the difference of their declinations as nearly as you can, and make the image which comes first run along the wire HOR, by elevating or depressing the telescope; and when the other star comes in, if it does not also run along HOR, alter the micrometer till it does, and half the sum of the numbers shown by the micrometer at the two separate observations of the two stars on the wire HOR will be the difference of their declination. That this should be true, it is manifestly necessary that the two segments should recede equally in opposite directions; and this is effected by Mr. Dollond in his new improvement of the object-glass micrometer.

The difference of right ascensions and declinations of Venus or Mercury in the sun's disc and the sun's limb may be thus found. Turn the wires, so that the north limb n, Plate CCCLXXV. Fig. 16, of the sun's image AB, or the north limb of the image V of the planet, may run along the wire RH, which therefore will then be parallel to the equator, and consequently C c a secondary to it; then separate the segments, and turn about the micrometer till the two images V, v, of the planet pass C c at the same time, and then, by separating the segments, bring the north limb of the northernmost image V of the planet to touch HR, at the time the northernmost limb n of the southernmost image AB of the sun touches it, and the micrometer shows the difference of declinations of the northernmost limbs of the planet and sun, for the reason formerly given, we having brought the northernmost limbs of the two innermost images V and AB to HR, these two being manifestly interior to v and the northernmost limb N of the image PQ. In the same manner, we take the difference of declinations of their southernmost limbs; and half the difference of the two measures (taking immediately one after another) is equal to the difference of the declinations of their centres, without any regard to the sun's or planet's diameters, or error of adjustment of the micrometer; for as it affects both equally, the difference is the same as if there were no error; and the difference of the times of the transits of the eastern or western limbs of the sun and planet over C c gives the difference of their right ascensions.

Instead of the difference of right ascensions, the distance of the planet from the sun's limb, in lines parallel to the equator, may be more accurately observed thus: Separate the segments, and turn about the wires and micrometer, so as to make both images V, v, Plate CCCLXXV. Fig. 17, run along HR, or so that the two intersections I, T of the sun's image may pass C c at the same time. Then bring the planet's and sun's limbs into contact, as at V, and do the same for the other limb of the sun, and half the difference gives the distance of the centre of the planet from the middle of the chord on the sun's disc parallel to the equator, or the difference of the right ascensions of their centres, allowing for the motion of the planet in the interval of the observations, without any regard to the error of adjustment, for the same reason as before. For if you take any point in the chord of a circle, half the difference of the two segments is manifestly the distance of the point from the middle of the chord; and as the planet runs along HR, (Plate CCCLXXV. Fig. 18,) the chord is parallel to the equator.

In like manner, the distances of their limbs may be measured in lines perpendicular to the equator, by bringing the micrometer into the position already described, and instead of bringing V to HR, separate the segments till the northernmost limbs coincide as at V; and in the same manner make their southernmost images to coincide, and half the difference of the two measures, allowing for the planet's motion, gives the difference of the declinations of their centres.

Hence the true place of a planet in the sun's disc may at any time of its transit be found; and consequently the nearest approach to the centre and the time of ecliptic conjunction may be deduced, although the middle should not be observed." *Phil. Trans.* 1771.

In using the divided object-glass micrometer, it has been found in practice to give different measures of the same angle at different times. This error arises from an alteration in the focus of the eye of the observer; for if the eye is not suited to see distinctly the intersection of the two pencils PF, QF, Fig. 13, at the point F, the two images will either appear separate or overlap one another, according as the eye is adapted to a nearer or a more distant object than F. In order to remedy this inconvenience, Dr Maskelyne contrived, in the year 1776, the prismatic micrometer, which we shall describe in his own words.

"Let ACB (Plate CCCLXXV. Fig. 19.) represent the object-glass, and *d* the eye-glass of a telescope, and PR a prism placed to intercept part of the rays coming from an object, suppose the sun, before they fall on the object-glass. The rays EE, proceeding from the eastern limb of the sun, and refracted through the object-glass ACB without passing through the prism, will form the corresponding point of the sun's image at *e*; and the rays WW proceeding in like manner from the western limb of the sun, will be refracted to form the correspondent point of the sun's image at *w*. But the rays 2E, 2E, 2W, 2W, proceeding in like manner from the eastern and western limbs of the sun, and falling on the prism PR, and thence refracted to the object-glass ACB, will, after refraction through it, form the correspondent points of the sun's image at 2*e*, 2*w*. Let the refraction of the prism be equal to the sun's apparent diameter: in this case, at whatever distance the prism be placed beyond the object-glass, the two images of the sun, *we*, 2*w* 2*e* will touch one another externally at the point *e*2*w*; for the rays 2W, 2W, proceeding from the western limb of the sun, being inclined to the rays EE, proceeding from the eastern limb in the angle of the sun's apparent diameter, will, after suffering a refraction in passing through the prism equal to the sun's apparent diameter, emerge from the prism, and fall upon the object-glass parallel to the rays EE, and consequently will have their focus 2*w* coincident with the focus *e* of the rays EE, and therefore the two images of the sun, *we*, 2*w*2*e*, will touch one another externally at the point *e*2*w*, and the instrument will measure the angle EC2W, and that only.

But if the prism be placed within the telescope, the angle measured by the instrument will be to the refraction of the prism as the distance of the prism from the focus of the object-glass is to the focal distance of the object-glass; or if two prisms be used to form the two images, with their refracting angles placed contrary ways, as represented in Plate CCCLXXV. Fig. 20, and 21. the angle measured will be to the sum of the refractions of the prisms as the distance of the prisms from the focus of the object-glass is to the focal distance of the object-glass. For let ACB (Fig. 20.) represent the object-glass, and *d* the eye-glass of a telescope, and PR, RS, two prisms interposed between them, with their refracting angles turned contrary ways, and the common sections of their refracting planes touching one another at R. The rays proceeding from an object, suppose the sun, will be disposed, by the refraction of the object-glass, to form an image of the sun at the focus; but part of them falling on one prism, and part on the other, will be thereby refracted contrary ways, so as to form two equal images *w e*, 2*w*2*e*, which, if the refractions of the prisms be of proper quantities, will touch one another externally at the point *e*2*w*. Let ECN be the axis of the pencil of rays EE proceeding from the sun's eastern limb; and WCO the axis of the pencil of rays WW proceeding from the sun's western limb; and the point N the place where the image of the sun's eastern limb would be formed, and the point O where that of the western limb would be formed, were not the rays diverted from their course by the refractions of the prisms. But, by this means, part of the rays EE, which were proceeding to N, falling on the prism PR, will be refracted, to form an image of the sun's eastern limb at *e*, while others of the rays EE, which fall on the prism RS, will be refracted, to form an image of the sun's eastern limb at 2*e*. In like manner, part of the rays WW, which were proceeding to form an image of the sun's western limb at O, falling on the prism RS, will be refracted, to form an image of the sun's western limb at 2*w* coincident with *e*, the point of the image correspondent to the sun's eastern limb: while others of the rays WW, which fall on the prism PR, will be refracted to form the image of the sun's western limb at *w*. The two images *w e*, 2*w*2*e*, are supposed to touch one another externally at the point *e*2*w*. The ray EFR, which belongs to the axis ECN, and is refracted by the prism PR to *e*, undergoes the refraction NR*e*, which (because small angles are proportional to their sines, and the sine of NR *e* is equal to the sine of its supplement NRC) is to NCR as NC or C *e* is to NR or R *e*. In like manner, the ray WGR, which belongs to the axis WCO, and is refracted by the prism RS to 2*w* or *e*, undergoes the refraction OR *e*, which is to OC *e* as OC or C *e* is to RO or R *e*: therefore, by composition, ORN, the sum of the refractions OR *e*, NR *e*, is to OCN, the sum of the angles OC *e*, NC *e*, or the sun's apparent diameter, as C *e* to R *e*; that is, as the focal distance of the object-glass to the distance of the prisms from the focus of the object-glass.

Or let the prisms PR, RS, be placed with their refracting angles P, S, turned from one another as in Plate CCCLXXV. Fig. 21, the refraction of the prism PR will transfer the image of the sun from ON to *w e*, and the refraction of the prism RS will transfer the image ON to 2*w*2*e*, the two images 2*w*2*e w e*, touching one another externally at the point 2*e w*. Let ECN, WCO, be the axes of the pencils of rays proceeding from the two extreme limbs of the sun, and N, O, the points where the images of the sun's eastern and western limbs would be formed by the object-glass, were it not for the refraction of the prisms; the ray EFR, which belongs to the axis ECN, and is refracted by the prism RS to $2e$, undergoes the refraction NR $2e$; and the ray WGR, which belongs to the axis WCO, and is refracted by the prism PR to w, undergoes the refraction OR w. Now NC $2e$, part of the angle measured, is to NR $2e$, the refraction of the prism RS, as R w to C w; and OC w, the other part of the angle measured, is to OR w, the refraction of the prism PR, in the same ratio of R w to C w: therefore OCN, the whole angle measured, is to ORN, the sum of the refractions of the two prisms, as R w to C w; that is, as the distance of the prisms from the focus of the object-glass to the focal distance of the object-glass.

When the prisms are placed in the manner represented in Fig 20, the point e of the image w e is illuminated only by the rays which fall on the object-glass between A and F. and the point $2w$ only by the rays which fall on the object-glass between B and G. Now the angles CRF, CRG, equal to the refractions of the prisms, being constant, the spaces FC, CG, will increase in proportion as the distances RF, RG, increase, and the spaces AF, GB, diminish as much; and therefore the images at the point of mutual contact, e 2 w, will be each illuminated by half the rays which fall on the object-glass when the prisms are placed close to the object-glass; but will be enlightened less and less, the nearer the prisms are brought to the focus of the object-glass.

But when the prisms are placed in the manner shewn in Fig. 21. the images at the point of contact, as the prisms are removed from the object-glass towards the eye-glass, will be enlightened with more than half the rays that fall on the object-glass, and will be most enlightened when the prisms are brought to the focus itself; for the point $2e$ of the image $2w2e$ will be enlightened by all the rays EE that fall on the object-glass between B and F, and the point w of the image w e will be enlightened by all the rays WW which fall on the object-glass between A and G. But the difference of the illuminations is not very considerable in achromatic telescopes, on account of the great aperture of the object-glass; as the greatest space FG is to the focal distance of the object-glass, as the sum of the sines of the refractions of the prisms is to the radius.

There is a third way, and perhaps the best, of placing the prisms, so as to touch one another along their sides which are at right angles to the common sections of their refracting planes. In this disposition of the prisms, the images will be equally enlightened, namely, each with half the rays which fall on the object-glass, wherever the prisms be placed between the object-glass and eye-glass.

From what has been shewn, it appears that this instrument, which may be properly called the prismatic micrometer, will measure any angle that does not exceed the sum of the refractions of the prisms, excepting only very small angles, which cannot be taken with it, on account of the vanishing of the pencils of rays at the juncture of the two prisms near the focus of the object-glass; that it will afford a very large scale, namely, the whole focal length of the object-glass for the greatest angle measured by it; and that it will never be out of adjustment; as the point of the scale where the measurement begins (or the point of O) answers to the focus of the object-glass, which is a fixed point for celestial objects, and a point very easily found for terrestrial objects. All that will be necessary to be done, in order to find the value of the scale of this micrometer, will be to measure accurately the distance of the prisms from the focus, when the instrument is set to measure the apparent diameter of any object subtending a known angle at the centre of the object-glass, which may be easily found by experiment, as by measuring a base, and the diameter of the object observed placed at the end of it, in the manner practised with other micrometers: for the angle subtended by this object will be to the angle subtended by a celestial object, or very remote land object, when the distance of the prisms from the principal focus is the same as it was found from the actual focus in the terrestrial experiment, as the principal focal distance of the object-glass is to the actual focal distance in the said experiment.

It will, I apprehend, be the best way in practice, instead of one prism to use two prisms, refracting contrary ways, and so divide the refraction between them (as represented in Fig. 20. and 21.) Achromatic prisms, each composed of two prisms of flint and crown-glass, placed with their refracting angles contrary ways, will undoubtedly be necessary for measuring angles with great precision by this instrument.

Two or more sets of prisms may be adapted to the same telescope, to be used each in their turn, for the more commodious measurement of different angles. Thus it may be very convenient to use one set of prisms for measuring angles not exceeding 36′, and consequently fit for measuring the diameters of the sun and moon, and the lucid parts and distances of the cusps in their eclipses; and another set of prisms to measure angles not much exceeding one minute, and consequently fit for measuring the diameters of all the other planets. This latter set of prisms will be the more convenient for measuring small angles, on account of a small imperfection attending the use of this micrometer, as before mentioned; namely, that angles cannot be measured with it when the prisms approach very near the focus of the object-glass, the pencils of rays being there lost at the point where the prisms touch one another."

This micrometer has not been found to answer in practice. In addition to the ordinary uncorrected colours of the object-glass, it is injured by the uncorrected colours of the achromatic prism, which most particularly affect the touching limbs.

A catoptric double image micrometer analogous to that of Dr. Maskelyne, but much more simple in its construction, in consequence of no additional prisms, lenses, or mirrors, being used, has lately been proposed by Dr. Brewster. It is applied to the Newtonian telescope, and has the advantage of not being affected by any change in the focal length of the eye An account of this micrometer will be found in the *Edinburgh Philosophical Journal* for 1820.

In the year 1779, the late ingenious Mr. Ramsden communicated to the Royal Society an account of two micrometers; a *catoptric* one, which formed two images by means of two semi-mirrors; and a *dioptric* one, which formed a double image by means of two semi-lenses placed in the eye-piece of the telescope

The first of these instruments is represented in Plate CCCLXXV. Fig. 22, and has been thus described by its inventor. "Beside the advantage it derives from the principle of reflection, of not being disturbed by the heterogeneity of light, it avoids every defect of other micrometers, and can have no aberration, nor any defect arising from the imperfection of materials or of execution; as the extreme simplicity of its construction requires no additional mirrors or glasses to those required for the telescope; and the separation of the images being effected by the inclination of the two specula, and not depending on the focus of any lens or mirror, any alteration in the eye of an observer cannot affect the angle measured. It has also the advantages of an adjustment, to make the images coincide in a direction perpendicular to that of their motion; and also of measuring the diameter of a planet on both sides of the zero, which will appear no inconsiderable advantage to observers who know how much easier it is to ascertain the contact of the external edges of two images than their perfect coincidence. In this micrometer, the small speculum A is divided into two equal parts; one of which is fixed on the end of the arm B, the other end of the arm is fixed on a steel axis X, which crosses the end of the telescope C. The other half of the mirror A is fixed on the arm D, which arm at the other end terminates in a socket *y*, that turns on the axis X; both arms are prevented from bending by the braces *a a*. G represents a double screw, having one part *e* cut into double the number of threads in an inch to that of the part *g*; the part *e* having 100 threads in one inch, and the part *g* 50 only. The screw *e* works in a nut F in the side of the telescope, while the part *g* turns in a nut H, which is attached to the arm B; the ends of the arms B and D, to which the mirrors are fixed, are separated from each other by the point of the double screw pressing against the stud *h*, fixed to the arm D, and turning in the nut H on the arm B. The two arms B and D are pressed against the direction of the double screw *e g*, by a spiral spring within the part *n*, by which means all shake or play in the nut H, on which the measure depends, is entirely prevented.

From the difference of the threads on the screw at *e* and *g*, it is evident that the progressive motion of the screw through the nut will be half the distance of the centres of the two halves of the mirror; and consequently the half mirrors will be moved equally in contrary directions from the axis of the telescope C.

The wheel V fixed on the end of the double screw has its circumference divided into 100 equal parts, and the index I shows the motion of the screw with the wheel round its axis, while the number of revolutions of the screw is shown by the divisions on the same index. The steel screw at R may be turned by the key S, and serves to incline the small mirror at right angles to the direction of its motion. The telescope itself has a motion round its axis for the conveniency of measuring the diameter of a planet in any direction; and the inclination of the diameter measured with the horizon is shown by a level and vernier on a graduated circle, at the breech of the telescope.

This micrometer will require a table for correcting a small error which arises from the eccentric motion of the half mirrors. By this motion their centres of curvature will approach a little towards the large mirror. The equation for this purpose in small angles is insensible; but when angles to be measured exceed ten minutes, it must not be neglected. Or, the angle measured may be corrected by diminishing it in the proportion the versed sine of the angle measured, supposing the eccentricity radius, bears to the focal length of the small mirror.

As the aberration is less in the Cassegrainian telescope than either in those of the Gregorian or Newtonian form, Mr. Ramsden preferred it for the application of this micrometer, the aberrations being nearly as 3 to 5.

Mr. Ramsden's dioptric micrometer, represented in Fig. 24, is applied to the erect eye-tube of a refracting telescope, and is placed between the third and fourth eye-glasses. In order to understand its application, let *x y*, Fig. 23, be the principal pencil of rays from the object-glass O; *t t* and *u u*, the axis of two oblique pencils; *a*, the first eye-glass; *m*, its conjugate focus, or the place of the micrometer; *b* the second eye-glass; *c* the third, and *d* the fourth, or that which is nearest the eye. Let *p* be the diameter of the object-glass, *e* the diameter of a pencil at *m*, and *f* the diameter of the pencil at the eye; it is evident, that the axes of the pencils from every part of the image will cross each other at the point *m*; and *e*, the width of the micrometer-glass, is to *p*, the diameter of the object-glass, as *m a* is to *g o*, which is the proportion of the magnifying power at the point *m*; and the error caused by an imperfection in the micrometer-glass placed at *m* will be to the error, had the micrometer been at O, as *m* is to *p*.

The micrometer itself is shewn in Fig. 24, where A is a convex or concave lens, bisected by a plane across its centre; one of these semi-lenses is fixed in a frame B, and the other in the frame E; which two frames slide on a plate H, and are pressed against it by thin plates *a a*: the frames B and E are moved in contrary directions by turning the button D: L is a scale of equal parts on the frame B; it is numbered from each end towards the middle. There are two verniers on the frame E, one at M, and the other at N, for the convenience of measuring the diameter of a planet, &c. on both sides the zero. The first division on both these verniers coincides at the same time with the two zeros on the scale L; and if the frame is moved towards the right, the relative motion of the two frames is shown on the scale by the vernier M; but if the frame B be moved towards the left, the relative motion is shown by the vernier N. This micrometer has a motion round the axis of vision, for the convenience of measuring the diameter of a planet, &c. in any direction, by turning an endless screw F, and the inclination of the diameter, which is measured to the horizon, is shown in the circle *g* by a vernier image. See Savary, *Phil. Trans.* 1753, p. 165. Bouguer, *Mem. Acad. Par.* 1748, p. 11, and *Hist.* p. 87. Dollond, *Phil. Trans.* 1753, p. 178, and 1754, p. 551. Maskelyne's *Phil. Trans.* 1771, p. 536, and 1777, p. 799, and Ramsden, *Phil. Trans.* 1779, p. 419.

CHAP. V.

On Double Image Micrometers, in which the Lenses or Mirrors are opened and shut optically.

The method of varying the angular distance of a pair of fixed wires has been successfully applied by Dr. Brewster to the construction of a divided object-glass micrometer, which possesses peculiar advantages. It is represented in Plate CCCLXXVI. Fig. 1, where LL is an achromatic object-glass, having two achromatic semi-lenses, A, B, represented in Fig. 2.

moveable between it and its principal focus f. These semilenses are completely fixed, so that their centres are invariably at the same distance; but the angle subtended by the two images which they form, is varied by giving them a motion along the axis O f of the lens LL. When the semilenses are close to LL, the two images are much separated, and form a great angle; but, as the lenses are moved towards f, the centres of the images gradually approach each other, and the angle which they form, is constantly increasing. By ascertaining, therefore, experimentally, the angle formed by the centres of the images, when the semilenses are placed close to LL, and also the angle which they subtend when the semilenses are at f, the other extremity of the scale, we have an instrument which will measure, with the utmost accuracy, all intermediate angles.

In constructing this micrometer for astronomical purposes, the semilenses may be made to move only along a portion of the axis O f, particularly if the instrument is intended to measure the diameters of the sun and moon, or any series of angles within given limits. By increasing the focal length of the semilenses, or by diminishing the distance between their centres, the angles may be made to vary with any degree of slowness, and of course each unit of the scale will correspond to a very small portion of the whole angle. The accuracy and magnitude of the scale, indeed, may be increased without limit; but it is completely unnecessary to carry this any farther than till the error of the scale is less than the probable error of observation.

Let us now examine the theory of this micrometer, and endeavour to ascertain the nature of the scale for measuring the variations of the angle. For this purpose, let LL, Fig. 1, be the object-glass, which forms an inverted image, $m\,n$, of the object MN, and let the semilenses AB, having their centres at an invariable distance, be interposed between the object-glass and its principal focus, in such a manner, that their centres are equidistant from the axis O f. Now, it is obvious, that the size of the image $m\,n$ is proportional to the size of the object MN; and, as the angle subtended by MN depends upon its size, the magnitude of the image $m\,n$ may, in the case of small angles, be assumed as a measure of the angle subtended by MN. As the rays which proceed from the point M are all converged to m by means of the lens LL alone, the ray b A, which passes through the centre of the semilens A, must of course have the direction $b\,m$; and, as it suffers no refraction in passing through the centre of A, it will proceed in the same direction b A m, after emerging from the semilens, and will cross the axis at F. For the same reasons the ray c B, proceeding from N, and passing through the centre of B, will cross the axis at F, as it advances to n. If the distance of F from A and B happens to be equal to the focal length of the lenses A and B, when combined with LL, distinct images of M and N will be formed at F, and they will appear to touch one another; and the line $m\,n$, being the size of the image that would have been formed by the lens LL alone, will be a measure of the angle subtended by the points M, N. If the point F, where the lines A m, B n cross the axis, should not happen to coincide with the focus of the lenses A, B, when combined with LL, then let this focus be at F′, nearer A and B than F. Draw the lines AF′ m, BF′ n, then it is obvious, that if the angle subtended by MN were enlarged, so as to be represented by $n'\,m'$, instead of $n\,m$, or so that the lens LL alone would form an image of it equal to $n'\,m'$, the point of intersection F would coincide with the focus F; so that, in every position of the lenses A, B, with respect to LL, the points M, N may always be made to subtend such an angle, that when they are placed before the telescope, the points F, F′ will coincide, and consequently the images of the points M, N will be distinctly formed at F′, and will be in contact. Whenever this happens, the space $n'\,m'$ will be a measure of the angle thus subtended by MN. Hence, it follows, that whatever be the position of the semilenses A, B, on the axis O f, the rays b A, c B, which pass through the centres of the semilenses, will cross the axis at some point F, corresponding with the focus of rays diverging from M, N, and will mark out the size of the image $n'\,m'$, and consequently the relative magnitude of the angle subtended by the two points M, N.

From the equality of the vertical angles AF′ B, n' F′ m', and the parallelism of the lines AB, $n'\,m'$, we shall have $n'\,m' : \mathrm{AB} = f\mathrm{F}' : \mathrm{GF}'$; and calling $f\mathrm{F}' = b$, and considering that $\mathrm{GF}' = \frac{\mathrm{F}\,b}{\mathrm{F}+b}$, F being the focal length of the semilenses, we have $n'\,m' : \mathrm{AB} = b : \frac{\mathrm{F}\,b}{\mathrm{F}+b}$, and consequently $n'\,m' = \mathrm{AB} + \frac{\mathrm{AB}\times b}{\mathrm{F}}$. Now, calling AB=2, F=10, and b=1, 2, 3, successively, we shall obtain

$$n'\,m' = 2 + \frac{2\times 1}{10} = 2.2$$

$$n'\,m' = 2 + \frac{2\times 2}{10} = 2.4$$

$$n'\,m' = 2 + \frac{2\times 3}{10} = 2\ 6$$

faom which it appears, that when b is in arithmetical progression, the angle $n'\,m'$ varies at the same rate, and consequently the scale which measures the variations of the angle, subtended by the centres of the two images, is a scale of equal parts.

This instrument undergoes a very singular change, when constructed as in Plate CCCLXXVI Fig. 3, so that the semilenses are outermost and immoveable, while another lens, LL, is made to move along the axis G f. In this case, a double image is formed as before, but the angle subtended by the centres of the images never suffers any change during the motion of the lens LL along the axis of the telescope. If the two images are in contact when the lens LL is close to the semilenses, they will continue in contact in every other position of LL; but the magnitude of the images is constantly increasing during the motion of LL towards f, the principal focus of the semilenses. The reason of this remarkable property will be understood from Fig. 3, where M, N, are two objects placed at such an angle, that the rays passing through the centres A, B, of the semilenses, cross the axis at F, the focus of the combined lenses for rays divergent from M and N In this case, distinct images of M and N will be formed at F, and will consequently be in contact If the lens LL is removed to the position L′ L′, the rays M m, N n, which are incident upon it at the points m and n, having the same degree of convergency as before, will be refracted to F′, the focus of the combined lenses for rays diverging from MN. Two distinct images of the object will therefore be formed at F′, and these images will still be in contact. In like manner, it may be shewn, that whatever be the position of the lens LL between G and *f*, the rays M*f*, N*f*, will cross the axis at a point coincident with the focus of the combined lenses, and will there form two images always in contact. Hence it follows, that though the magnifying power of the instrument is constantly changing with the position of the lens LL, yet the angle subtended by the centres of the two images never suffers the least variation.

The application of the divided object-glass micrometer to a telescope for measuring distances, and to a coming-up glass for ascertaining whether a ship is approaching to, or receding from, the observer, will be found in Dr. Brewster's *Treatise on New Philosophical Instruments*, Book III Chap II

The principle upon which this instrument is founded may also be applied to Ramsden's dioptric micrometer, and to the reflecting micrometer which we have described in Chap. III. as applied to a Cassegrainian or Gregorian telescope.

CHAP. VI.

On Angular or Position Micrometers.

The first micrometer of this kind, that we are acquainted with, was invented and used by Sir William Herschel, for the purpose of measuring the angle which a line joining the two stars that compose a double star, forms with the direction of their apparent motion. The object which this celebrated astronomer had in view, was to verify a conjecture that the smaller of the two stars revolved round the greater, or rather round their common centre of gravity; and he actually found, by means of this instrument, that in the double star of Castor this revolution was performed in 342 years.

"The position micrometer is shown in Plate CCCLXXVI. Fig. 4, inclosed in a turned case of wood, as it is put together ready to be used with the telescope. A is a little box which holds the eye-glass. B is the piece which covers the inside work, and the box A is screwed into it. C is the body of the micrometer containing the brass work, showing the index plate *a* projecting at one side, where the case is cut away to receive it. D is a piece, having a screw *b* at the bottom, by means of which the micrometer is fastened to the telescope. To the piece C is given a circular motion, in the manner the horizontal motion is generally given to Gregorian reflectors, by the lower part going through the piece D, where it is held by the screw E, which keeps the two pieces C and D together, but leaves them at liberty to turn on each other

Fig. 5, is a section of the case containing the brass work, where may be observed the piece B hollowed out to receive the box A, which consists of two parts inclosing the eye lens. This figure also shows how the piece C passes through D, and is held by the ring E: the brass work, consisting of a hollow cylinder, a wheel and pinion, and index plate, is there represented in its place. F is the body of the brass work, being a hollow cylinder with a broad rim C at the upper end; this rim is partly turned away to make a bed for the wheel *d*. The pinion *e* turns the wheel *d*, and carries the index plate *a*. One of its pivots moves in the arm *f*, screwed on the upper part of *c*, which arm serves also to confine the wheel *d* to its place on *c*. The other pivot is held by the arm *g* fastened to F.

Fig. 6, is a plan of the brass work. The wheel *d*, which is in the form of a ring, is laid on the upper part of F or C, and held by two small arms *f* and *h* screwed down to *e* with the screws *i*, *i*.

Fig. 7, is a plan of the brass work; *d*, *d* is the wheel placed on the bed or socket of the rim of the cylinder *c*, *c*, and is held down by the two pieces *f*, *h*, which are screwed on *c*, *c*. The piece *f* projects over the centre of the index plate to receive the upper pivot of the pinion *m*, *n*, the fixed wire fastened to *c*, *c* *o*, *p*, the moveable wire fastened to the annular wheel *d*, *d*. The index plate *a* is divided into 60 parts, each sub-divided into two, and milled on the edge. When the finger is drawn over the milled edge of the index plate from *q* towards *r*, the angle *mso* will open, and if drawn from *r* towards *q*, it will shut again. The case *c*, *c*, must have a sharp corner *t*, which serves as a hand to point out the divisions on the index plate." *Phil. Trans.* 1781, p. 509.

In this instrument, the two wires always cross each other at the centre of the field, and consequently their angular separation is produced uniformly by the motion of the pinion. This very circumstance, however, which, though it renders it easy for the observer to read off the angle from the scale, is one of the greatest imperfections of the instrument. The observations must obviously be all made on one side of the centre of the field, as appears from Plate CCCLXXVI. Fig. 8, and the use of the instrument is limited to those cases in which S *s* is less than the radius SC The greatest disadvantage of the instrument, however, is the shortness of the radius SC, for the error of observation must always diminish as the length of this radius increases. This disadvantage does not exist in measuring the angle of position of two stars S. *s*, for the distance S *s* remains the same whatever be the length of SC, but in determining all other angles contained by lines, whose apparent length is greater than SC, this imperfection is inseparable from the instrument. Nay, there are some cases in which the instrument completely fails; as, for instance, when we wish to measure the angle formed by two lines which do not meet in a point, but only tend to a remote vertex. If the distance of the nearest extremities of these lines is greater than the chord of the angle which they form, measured upon the radius SC, then it is impossible to measure that angle, for the lines cannot be brought to coincide with the two lines by which it is contained. Nay, when the chord of the angle does exceed the distance between the nearest extremities, the portion of the wires that can be brought into coincidence with the lines is so small, as to lead to very serious errors in the result

The new angular micrometer, which we venture to propose as a substitute for this instrument, is completely free from the defects which we have just noticed, and is founded on a very beautiful property of the circle. If any two chords AB, CD, Plate CCCLXXVI. Fig. 9, intersect each other in the point O within the circle, the angle which they form at O will be equal to half the sum of the arches AC, BD; but if these chords do not intersect each other within the circle, but tend to any point

O without the circle, as in Fig. 10, then the angle which they form is equal to half the difference of the arches AC, BD; that is, calling ϕ the angle, we have in the first case $\phi = \frac{AC+BD}{2}$, and in the second case $\phi = \frac{AC-BD}{2}$. Hence if AB, CD be two wires, placed in the focus of the first eye-glass of a telescope, the moveable one AB may be made to form every possible angle with the fixed one CD, and that angle may be readily found from the arches AB, CD.

The apparatus by which these arches are measured is represented in Plate CCCLXXVI. Fig. 11, where the graduated circular head may be divided only into 180°, in order to save the trouble of halving the sum, or the difference of the arches AC, BD; but as it would still be necessary to measure *two* arches before the angle could be ascertained, we have adopted another method, remarkable for its simplicity, and giving no more trouble than if the wires always intersected each other in the centre of the field.

Let AB, for example, Plate CCCLXXVI. Fig. 9. be the fixed wire, and CD the moveable one, and let it be required to find, at one observation, the angle AOC or φ. Let the index of the vernier be at zero, when the point D coincides with B; and as it is obvious that the extremity C will be at c when D is at B, the arch c A will be a constant quantity, which we shall call b. Making AC $=m$ and BD$=n$, we have, $\varphi = \frac{m+n}{2}$; but since the extremity C will move over the space C c while D describes the space DB, these arches must be equal, consequently $b = m - n$; hence, adding 2 n to each side of the equation, we obtain $b + 2n = m + n$, or $\frac{1}{2} b + n = \frac{m+n}{2}$, consequently $\varphi = \frac{1}{2} b + n$. Hence the angle AOC is equal to half the arch A c added to the arch DB; or since A c is invariable, the half of it is a constant quantity, and the angle required is equal to the sum of this constant quantity and the arch DB.

When the wires do not intersect each other, as in Fig. 10, we have $\varphi = \frac{m-n}{2}$ and $b = m + n$; hence, subtracting 2 n from each side of the equation, we have $b - 2n = m - n$, and dividing by 2 $\frac{1}{2} b - n = \frac{m-n}{2}$, consequently $\varphi = \frac{1}{2} b - n$. That is, the angle AOB is equal to the difference between half the arch A c and the arch DB, or to a constant quantity, diminished by the arch DB.

In finding the angle AOB, therefore, we have merely to observe the place of the index when the wires are in their proper position; and as the scale commences at B, or when D and B coincide, and is numbered both ways from B, the degree pointed out on the circular head, when increased or diminished by the constant quantity, will give the angle of the wires which is sought. The semicircle on each side of a diameter drawn through B, is divided into 180°, the 180th degree being at the opposite end of that diameter.

The method of reading off the angle AOB may be still farther simplified, so as to save the trouble even of recollecting the constant quantity, and of adding and subtracting it from the arch pointed out by the index of the vernier. This effect is produced by making the index of the vernier point to the constant quantity upon the part of the scale below B, Fig. 9, when the points D, B, coincide, or when the wire CD is in the position c B; for it is obvious that if z is the zero of the scale, and B z equal to the constant quantity, the arch D z, which is pointed out by the index of the vernier, will be equal to $\frac{1}{2} b + n$, or the angle AOB. In like manner, in Fig. 10, where the wires do not cross each other within the field, and where B z is the constant quantity, the arch D z, marked out by the index of the vernier, is obviously equal to $\frac{1}{2} b - n$, or the angle AOB, which the wires tend to form at O. By means of this adjustment, therefore, we are enabled to read off the angle AOB with the same facility as if the wires intersected each other in the very centre of the field, when the arches are accurate measures of the angles at the centre.

It is not necessary that the two wires should be placed in the focus of the first eye-glsss. Dr. Brewster has constructed an instrument of this kind, in which the fixed wire AB is placed in the focus of the whole eye-piece, or, what is the same thing, in the focus of the object-glass, while the moveable wire CD revolved in the focus of the first eye-glass. In this case the wire AB is more magnified than the other; but if this should be regarded as an inconvenience, it might easily be removed by using a more delicate fibre.

The end of the eye-tube is represented in Fig. 11, where CD is the circular head, divided into 360°, and subdivided by the vernier V; L is the level, and AB the part of the eye-piece which contains the diaphragm with the fixed and moveable wires. The head CD, and the level L, are firmly fixed to the eye-tube T, and from the head CD there rises an annular shoulder concentric with the tube, and containing the diaphragm across which the fixed wire is stretched. This diaphragm, which is represented in Plate CCCLXXVI. Fig. 12. with the wire extended across, projects through the circle of brass EF. All these parts remain immoveable, while the outer tube AB, and the other half EF of the circular head which contains the vernier V, have a rotatory motion upon the shoulder which rises from CD. The tube AB is merely an outer case to protect a little tube within it, which contains the eye-glass, and the moveable diaphragm with its fibre extended across it. The inclosed tube is screwed into the ring EF, and the outer tube is also screwed upon the same ring; so that by moving AB, a motion of rotation is communicated to the vernier V, and to the diaphragm and wire belonging to the inner tube, while the rest of the eye-piece, containing the other diaphragm with its wire, remains stationary. By this means the moveable wire is made to form every possible angle with the fixed wire, and the angle is determined by the method which we have already explained. The fixed wire is placed a little out of the centre of the diaphragm to which it belongs, and the diaphragm itself is placed in a cell, in which it can be turned round, so as to adjust the wire to a horizontal line, when the level is set. The moveable wire is likewise placed at a little distance from the centre of its diaphragm, as represented in Plate CCCLXXVI. Fig. 13; but by means of screws which pass through the inner tube into the edge of this diaphragm, it can be moved in a plane at right angles to the axis of the eye-piece, so that the moveable wire may be placed either in the centre of the field, or at different distances from it. See *Treatise on New Phil. Inst.* p. 112.

CHAP. VII.

On Lucid Disc, and Luminous Image Micrometers.

In measuring the distance of close double stars, Sir William Herschel found it difficult to apply the common wire micrometer, from the various sources of imperfection to which it is liable, but particularly from the necessity of illuminating the wires. He, therefore, set himself to construct a micrometer for this particular purpose, and in this way he contrived the lamp micrometer.

This instrument is represented in Plate CCCLXXVI. Fig. 14. "where ABGCFE is a stand nine feet high, on which a semicircular board *q h o g p* is moveable upward or downward, in the manner of some fire-screens, as occasion may require, and is held in its situation by a peg *p* put into any one of the holes of the upright piece AB. This board is a segment of a circle of 14 inches radius, and is about three inches broader than a semicircle, to give room for the handles *r* D, *e* P, to work. The use of this board is to carry an arm L, 30 inches long, made to move on a pivot at the centre of the circle, by means of a string, which passes in a groove on the edge of the semicircle *p g o h q*; the string is fastened to a hook *o*, (not expressed in the figure, being at the back of the arm L,) and, passing along the groove from *o h* to *q*, is turned over a pulley at *q*, and goes down to a small barrel *e*, within the plane of a circular board, where a double jointed handle *e* P commands its motion. By this contrivance we see the arm L may be lifted up to any altitude from the horizontal position to the perpendicular, or be suffered to descend by its own weight below the horizontal to the reverse perpendicular situation. The weight of the handle P is sufficient to keep the arm in any given position; but if the motion should be too easy, a friction spring applied to the barrel will moderate it at pleasure.

In front of the arm L a small slider, about three inches long, is moveable in a rabbet from the end L towards the centre, backward and forward. A string is fastened to the left side of the little slider, and goes towards L, where it passes round a pulley at *m*, and returns under the arm from *m n*, towards the centre, where it is led in a groove on the edge of the arm, which is of a circular form, upward to a barrel (raised above the plane of the circular board) at *r*, to which the handle *r* D is fastened. A second string is fastened to the slider, at the right side, and goes towards the centre, where it passes over a pulley *n*, and the weight *w*, which is suspended by the end of the string, returns the slider towards the centre, when a contrary turn of the handle permits it to act.

Two small lamps, 2 inches high, $1\frac{1}{2}$ in breadth, by $1\frac{1}{4}$ in depth, are shown at *a* and *b*. The sides, back, and top, are made so as to permit no light to be seen, and the front consists of a thin brass sliding door. The flame in the lamp *a* is placed $\frac{5}{10}$ths of an inch from the left side, $\frac{3}{10}$ths from the front, and half an inch from the bottom. In the lamp *b* it is placed at the same height and distance, measuring from the right side. The wick of the flame consists only of a very thin lamp-cotton thread; for the smallest flame being sufficient, it is easier to keep it burning in so confined a place. In the top of each lamp must be a little slit, lengthways, and also a small opening in one side near the upper part, to permit air enough to circulate, to feed the flame. To prevent every reflection of light, the side opening of the lamp *a* should be to the right, and that of the lamp *b* to the left. In the sliding door of each lamp is made a small hole with the point of a very fine needle, just opposite the place where the wicks are burning, so that when the sliders are shut down, and every thing dark, nothing shall be seen but two fine lucid points of the size of two stars of the third or fourth magnitude. The lamp *a* is placed so, that its lucid point may be in the centre of the circular board, where it remains fixed. The lamp *b* is hung to the little slider which moves in the rabbet of the arm, so that its lucid point, in a horizontal position of the arm, may be on a level with the lucid point in the centre. The moveable lamp is suspended on a piece of brass fastened to the slider by a pin exactly behind the flame on which it moves as a pivot. The lamp is balanced at the bottom by a leaden weight, so as always to remain upright, when the arm is either lifted above, or depressed below the horizontal position. The double-jointed handles *r* D, *e* P, consist of light deal rods, ten feet long, and the lowest of them may have divisions, marked on it near the end P, expressing exactly the distance from the central lucid point, in feet, inches, and tenths.

From this construction we see, that a person at a distance of ten feet may govern the two lucid points, so as to bring them into any required position, south or north, preceding or following, from 0° to 90°, by using the handle P, and also to any distance from $\frac{6}{10}$ths of an inch to 5 or 6 and 20 inches, by means of the handle D. If any reflection or appearance of light should be left from the top or sides of the lamps, a temporary screen, consisting of a long piece of pasteboard, or a wire frame covered with black cloth, of the length of the whole arm, and of any required breadth, with a slit of half an inch broad in the middle, may be affixed to the arm by four bent wires, projecting an inch or two before the lamps, situated so that the moveable lucid point may pass along the opening left for that purpose.

Plate CCCLXXVI. Fig. 15. represents part of the arm L, of a larger size; *s* the slider; *m* the pulley, over which the chord *x l y z* is returned towards the centre; *v* the other chord going to the pulley *n* of Fig. 14; R the brass piece moveable on the pin *c*, to keep the lamp upright. At R is a wire rivetted to the brass piece, on which is held the lamp by a nut and screw. Fig. 16, 17. represent the lamps *a*, *b*, with the sliding doors open, to show the situation of the wicks. *w* is the leaden weight, with a hole in it *d*, through which the wire R of Fig. 15. is to be passed, when the lamp is to be fastened to the slider *s*. Fig. 18. represents the lamp *a* with the sliding door shut; *l* the lucid point; *i k* the openings at the top, and *s* at the sides for the admission of air.

The ingenious artist will soon perceive that the motions of this micrometer are capable of great improvement by the application of wheels and pinions, and other well known mechanical resources; but, as the principal object is only to be able to adjust the two lucid points to the required position and distance, and to keep them there for a few minutes, while the observer goes to measure their distance, it will not be necessary to say more on the subject.

Sir William Herschel next proceeds to show the application of this instrument. It is well known to opticians, and others, who have been in the habit of using optical instruments, that we can with one eye look into a microscope or telescope, and see an object much magnified, while the naked eye may see a scale on which the magnified picture is thrown. In this manner Sir W. Herschel generally determined the power of his telescopes; and any one who has acquired a facility of taking such observations will very seldom mistake so much as one in fifty in determining the power of an instrument, and that degree of exactness is fully sufficient for the purpose.

The Newtonian form is admirably adapted to the use of this micrometer; for the observer stands always erect, and looks in a horizontal direction, though the telescope should be elevated to the zenith. Besides, his face being turned away from the object to which his telescope is directed, this micrometer may be placed very conveniently, without causing the least obstruction to the view: therefore, in using this instrument, it is put at ten feet distance from the left eye, in a line perpendicular to the tube of the telescope, and the moveable board raised to such a height, that the lucid point of the central lamp may be on a level with the eye. The handles, lifted up, are passed through two loops fastened to the tube, just by the observer, so as to be ready for his use. It should be observed, that the end of the tube is cut away, so as to leave the left eye entirely free to see the whole micrometer.

Having now directed the telescope to a double star, it is viewed with the right eye, and at the same time with the left see it projected on the micrometer; then, by the handle P, which commands the position of the arm, it is raised or depressed so as to bring the two lucid points to a similar situation with the two stars; and, by the handle D, the moveable lucid point is approached or removed to the same distance of the two stars, so that the two lucid points may be exactly covered by, or coincide with the stars. A little practice in this business soon makes it easy, especially to one who has already been used to look with both eyes open.

What remains to be done is very simple. With a proper rule, divided into inches and 40th parts, the distance of the lucid points is taken, which may be done to the greatest nicety, because, as observed before, the little holes are made with the point of a very fine needle. The measure thus obtained is the tangent of the magnified angle under which the stars are seen, to a radius of 10 feet; therefore, the angle being found, and divided by the power of the telescope, gives the real angular distance of the centres of a double star. For instance, Sept. 25, 1781, Sir William Herschel measured α Herculis with this instrument. Having caused the two lucid points to coincide exactly with the stars centre on centre, he found the radius, or distance of the central lamp from the eye, 10 feet 4.15 inches; the tangent or distance of the two lucid points 50.6 fortieth parts of an inch; this gives the magnified angle 35′, and dividing by the power 460, which he used, he obtained 4″ 34‴ for the distance of the centres of the two stars. The scale of the micrometer at this very convenient distance, with the power of 460 (which his telescope bears so well on the fixed stars that for near a twelvemonth past he hardly used any other) is above a quarter of an inch to a second; and by putting on his power of 932, which in very fine evenings is extremely distinct, he obtained a scale of more than half an inch to a second, without increasing the distance of the micrometer; whereas the most perfect of his former micrometers, with the same instrument, had a scale of less than the 2000th part of an inch to a second.

The measures of this micrometer are not confined to double stars only, but may be applied to any other objects that require the utmost accuracy, such as the diameters of the planets or their satellites, the mountains of the moon, the diameters of the fixed stars, &c. For instance, Oct. 22, 1781, Sir William Herschel measured the apparent diameter of α Lyræ; and judging it of the greatest importance to increase his scale as much as convenient, he placed the micrometer at the greatest convenient distance and (with some trouble, for want of longer handles, which might easily be added) took the diameter of this star, by removing the two lucid points to such a distance as just to inclose the apparent diameter. When he measured his radius, it was found to be 22 feet 6 inches. The distance of the two lucid points was about three inches; for extreme nicety could not be obtained in this observation, on account of the very great power he used, which was 6450. From these measures we have the magnified angle 38′ 10″: this divided by the power gives 0″.355 for the apparent diameter of α Lyræ. The scale of the micrometer, on this occasion, was no less than 8.443 inches to a second, as will be found by multiplying the natural tangent of a second with the power and radius in inches. In Nov. 1781, he measured the diameter of the new star; but the air was not very favourable, for this singular star was not so distinct with 227 that evening as it generally is with 460: therefore, without laying much stress on the exactness of the observation, he only reports it, to exemplify the use of his micrometer. His radius was 35 feet 11 inches. The diameter of the star, by the distance of the lucid points, was 2.4 inches, and the power he used 227: hence the magnified angle is found 19′, and the real diameter of the star 5″.022. The scale of this measure is .474 millesimals of an inch, or almost half an inch to a second."

A lucid disc micrometer was also used by M. Schroeter of Lilienthal, in his observations on the new planets, but we are not acquainted with the principles of its construction.

A luminous image micrometer, in which the angle, subtended by two lucid points, is measured by expanding them into circular discs, and marking the instant of contact, has been described by Dr. Brewster in his *Treatise on New Philosophical Instruments*, p. 40.

CHAP. VIII.

On Doubly Refracting Micrometers.

The first person who proposed to employ the separation of two images, formed by double refraction, as the principle of a micrometer, was the late ingenious Abbé Rochon. On the 5th March 1777, Messrs. Leroi, Lemonnier, and Condorcet, gave a favourable report of this new invention, which was brought to a considerable degree of perfection by successive improvements, with which M. Rochon was constantly occupied till the time of his death, which took place in 1817.

If we suppose ABC, (Plate CCCLXXVI. Fig. 19.) a prism of rock crystal, so cut out of the hexaedral prism in which this substance is generally formed, that AC is the axis of the prism, and BCD another prism, so cut out of the same crystal, that BC is the axis of the prism, then a ray of light RR incident perpendicularly at R, will go on to R′ without being divided into two pencils, as the doubly refracting force vanishes in the direction of the axis; but when it reaches R′ it will be divided into two pencils R′ R″, R′ ϱ, one of which, R R″, the ordinary pencil, will go on in the direction R′ E without any deviation, as it is in no way affected with the doubly refracting force of the second prism BCD, while the extraordinary pencil R′ ϱ will deviate from the line R′ E, in virtue of the doubly refracting force of the second prism BCD. An eye placed at E will obviously not receive the two rays R′ E and R′ ϵ, but if we draw E r'', r'' r', r' r respectively parallel to ϵ ϱ, ϱ R′, r'' R′ R, a ray r r incident perpendicularly at r, will give an extraordinary ray r'' E, which will reach the eye E at the same time with the ordinary ray R′ E, and the observer will see two distinct images of the object from which these rays proceed.

In order to apply this compound prism to the purposes of a micrometer, M. Rochon introduces it between the object-glass and the eye-glass of an astronomical telescope, as shown in Plate CCCLXXVI. Fig. 20; and by moving it along the axis of the telescope, the angular separation of the two images of the object s s' is made to vary in a manner similar to what has been already described in the prismatic micrometer of Dr. Maskelyne.

In the year 1812, M. Rochon proposed another form of his micrometer, from which he expected great advantages. He took a parallelopiped of rock crystal, formed of two prisms, cut with angles of about 30°, and so as to make the images of the sun overlap one another about five minutes. When joined together by mastic, it was ground into a convex lens, and was united with a concave lens of glass, so as to form an achromatic object-glass. The object-glass, which had a focal length of about three decimeters, separated the centres of the images of the sun about 28 minutes. He then adapted to this object-glass a common micrometer, which measured angles of 10 minutes, and he had thus three decimetres or 10 minutes to complete the measure of the diameters of the sun or moon.

Ingenious as these micrometers are, we conceive them to be liable to an objection of a very serious nature. Dr. Brewster has shown, from numerous experiments, that rock crystal is very imperfectly crystallized in the direction of its axis, and that it exhibits great deviations from a homogeneous texture, both in its action upon common and polarised light. Distinct images therefore cannot be formed through prisms or lenses whose refracting surfaces are perpendicular, or nearly so, to the axis of the hexaedral prism. If astronomy therefore is to derive any advantage from doubly refracting micrometers, we must have recourse to the double refraction of other substances than rock crystal.

CHAP. IX.

On Micrometers for Microscopes.

Microscopical micrometers are generally employed for measuring very minute spaces, such as the subdivisions of astronomical instruments, or the diameters of objects magnified in the field of a microscope. All the micrometers described in chapter first, may be considered as micrometers of this kind, when placed in the anterior focus of the eye-glass of a microscope.

One of the simplest micrometers for microscopes, consists of a screw with an index, fixed in the focus of the eye-glass. The point of the screw is made to move across the space to be measured; and as the index registers the number of revolutions necessary for this purpose, the diameter of the object will be found by ascertaining the number of threads in one inch.

Dr. Jurin measured the magnitudes of minute objects, by comparing them with small pieces of silver or brass wire placed beside them; the diameter of which had been previously ascertained by coiling it round a cylinder, and observing how many breadths of the wire were contained in a given number of inches.

One of the best microscopical micrometers is the single lens micrometer, invented by Dr. Wollaston. This instrument, says Dr. Wollaston, is furnished with a single lens of about $\frac{1}{12}$th of an inch focal length. The aperture of such a lens is necessarily small, so that when it is mounted on a plate of brass, a small perforation can be made by the side of it in the brass, as near to its centre as $\frac{1}{25}$th of an inch.

When a lens thus mounted is placed before the eye for the purpose of examining any small object, the pupil is of sufficient magnitude for seeing distant objects at the same time through the adjacent perforation, so that the apparent dimensions of the magnified image might be compared with a scale of inches, feet, and yards, according to the distance at which it might be convenient to place it.

A scale of smaller dimensions attached to the instrument will, however, be found preferable on account of the steadiness with which the comparison may be made; and it may be seen with sufficient distinctness by the naked eye, without any effort of nice adaptation, by reason of the smallness of the hole through which it is viewed.

The construction that I have chosen for the scale is represented in Plate CCCLXXVI. Fig. 21. It is composed of smalls wires about $\frac{1}{50}$th of an inch in diameter, placed side by side, so as to form a scale of equal parts, which may be with ease counted by means of a certain regular variation of the lengths of the wires.

The external appearance of the whole instrument is that of a common telescope consisting of three tubes. The scale occupies the place of the object-glass, and the little lens is situated at the smaller end, with a pair of plain glasses sliding before it, between which the subject of examination is to be included. This part of the apparatus is shown separately in Fig. 23. It has a projection, with a perforation, through which a pin is inserted, to connect it with a screw represented at *b*, Fig. 22. This screw gives lateral motion to the object, so as to make it correspond with any particular part of the scale. The lens has also a small motion of adjustment, by means of the cap *c*, Fig. 22, which renders the view of the magnified object distinct.

Before the instrument is completed, it is necessary to determine with precision the indications of the scale, which must be different, according to the distance to which the tube is drawn out. In my instrument, one division of the scale corresponds to $\frac{1}{10000}$th of an inch, when it is at the distance of 16.6 inches from the lens; and since the apparent magnitude in small angles varies in the simple inverse ratio of this distance, each division of the same scale will correspond to $\frac{1}{5000}$th, at the distance of 8 $\frac{3}{10}$ inches, and the intermediate fractions $\frac{1}{6000}$, $\frac{1}{7000}$. &c. are found by intervals of

1.66 inch, marked on the outside of the tube. The basis on which these indications were founded in this instrument, was a wire, carefully ascertained to be $\frac{1}{20}$ of an inch in diameter, the magnified image of which occupied fifty divisions of the scale, when it was at the distance of 16.6 inches; and hence one division$=\frac{1}{50\times200}=\frac{1}{10000}$. Since any error in the original estimate of this wire must pervade all subsequent measures derived from it, the substance employed was pure gold, drawn till fifty two inches in length weighed exactly five grains. If we assume the specific gravity of gold to be 19.36, a cylindrical inch will weigh 3837 grains; and we may thence infer the diameter of such a wire to be $\frac{1}{200}$ of an inch, more nearly than can be ascertained by any other method.

For the sake of rendering the scale more accurate, a similar method was in fact pursued with several gold wires of different sizes, weighed with equal care; and the subdivisions of the exterior scale were made to correspond with the average of their indications.

In making use of this micrometer for taking the measure of any object, it would be sufficient, at any one accidental position of the tube, to note the number on the outside as denominator, and to observe the number of divisions and decimal parts which the subject of examination occupies on the interior scale as numerator of a fraction, expressing its dimensions in proportional parts of an inch; but it is preferable to obtain an integer as numerator by sliding the tube inward or outward, till the image of the wire is seen to correspond with some exact number of divisions, not only for the sake of greater simplicity in the arithmetical computations, but because we can by the eye judge more correctly of actual coincidence than of the conparative magnitudes of adjacent intervals. The smallest quantity which the graduations of this instrument profess to measure, is less than the eye can really appreciate in sliding the tube inward or outward. If, for instance, the object measured be really $\frac{1}{9900}$, it may appear $\frac{1}{10000}$, or $\frac{1}{9800}$, in which case the doubt amounts to $\frac{1}{50}$ part of the whole quantity. But the difference is here exceedingly small in comparison to the extreme division of other instruments where the nominal extent of its power is the same. A micrometer with a divided eye-glass, may profess to measure as far as $\frac{1}{10000}$ of an inch; but the next division is $\frac{2}{10000}$ or $\frac{1}{5000}$; and though the eye may be able to distinguish that the truth lies between the two, it receives no assistance within $\frac{1}{2}$ part of the larger measure."—*Phil. Trans.* 1813, p. 119.

In this ingenious instrument, where the variation of the scale is produced by placing the scale of wires at different distances from the observer, it is necessary that the scale be viewed by the naked eye, which by its adapting power can command distinct vision of it at different distances. We conceive, however, that it would be of advantage to have the scale at a permanent distance, and to view both the scale and the object to be measured with the aid of a lens, which may be easily done by placing a lens upon the small perforation. In this case it would be necessary to obtain a variation of the scale by means entirely different from those adopted by Dr. Wollaston.

A micrometer founded upon these principles has been proposed by Dr. Brewster, and may be easily constructed by a slight addition to a good kaleidoscope. Let ABC (Plate CCCLXXVI. Fig. 24.) be the aperture of the reflectors, and let *a b*, *d e* be the portion of a wire $\frac{1}{10}$th of an inch in diameter, that is seen directly through the aperture. When the wire is perpendicular to the reflector BC, its image *b c*, *e f* will coincide with the wire itself, and form an exact continuation of it. If we now turn round the cap till the wire comes into the position $a'\,b'$, $d'\,e'$, its reflected image $b'\,c'$, $e'\,f'$ will be inclined to the wire, and the thickness $b'\,e'$, or the oblique section of the wire, will be to its thicknes *b e* or $\frac{1}{10}$th of an inch as the secant of the arch (A) through which the wire has passed in going from the position *a b*, *d e* into the position $a'\,b'$, $d'\,e'$, is to 1, that is $b'\,e'=b\,e\times\sec.\,A=\frac{1}{10}\times\sec.\,A$. In this way the thickness of any wire may be made to vary and form a scale by which any other object may be measured by projecting against it, if it be very minute, and by juxta position if it is nearly of the same size. The unit of the scale, or *a b d e*, may be either a wire as already mentioned, or a luminous aperture, or the interval between two wires; and in order that the arch A may be always small, in which case the secants vary slowly, different units or standards may be fixed upon the cap of the instrument, which is divided into degrees for the purpose of measuring the arch A.

When the object is very minute, it must be placed in the focus of a magnifying lens, while the eye looks at the scale either through a perforation in that lens, if it has a considerable focal length, or at its side, if it has a small focal length. If the object is not microscopical, as ABCD, it may be measured by introducing it at the object end of the instrument, and having raised the standard scale *a m n d* till its oblique section *m n* is exactly equal to the diameter of the object ABCD. It is unnecessary to enter into any farther details respecting this instrument, as our only object at present is to explain the principle on which it is founded.

A similar instrument may be made by means of a doubly refracting plate placed at the upper end of a tube. A rectangular aperture is placed before this plate, of such a magnitude that its two images are exactly in contact when they are parallel to each other. By giving a rotatory motion of 90° to the rectangular aperture, the two apertures coincide in the direction of their length, and we have an arch of 90° to measure the variation. The breadth of the compound aperture will always be $A+A\sin.\,\phi$, A being the breadth of the rectangular aperture, and the ϕ arch described by the aperture reckoned from the longitudinal coincidence of the two images.

The principle of double refraction may be advantageously employed in the construction of a micrometer for measuring directly the magnitudes of objects of extreme minuteness. Let it be required, for example, to measure objects whose diameters are between the $\frac{1}{500}$th and $\frac{1}{5000}$th of an inch. Take a plate of rock crystal AB, CD (Plate CCCLXXVI. Fig. 25.) about two inches long, whose thickness AB at one end is ten times greater than its thickness CD at the other, and let the plate be cut out of the crystal, so that the two images of a wire $\frac{1}{500}$th of an inch in diameter will be in accurate contact, then at the other end CD, the two images of a wire $\frac{1}{5000}$th of an inch in diameter will be in accurate contact, and wires, or objects of all intermediate magnitudes, will be measured by observing the part of the scale between A and C, where their two images are in contact. This scale being two inches long may consist of a plate of mother-of-pearl attached to the rock crystal, and divided into 400 parts, so that each division will correspond to the $\frac{4500}{400}$, or a little more than $\frac{1}{1002}$dth parts of an inch. A prism of crown glass is cemented to the prism of rock crystal, in order to correct the dispersion, and a lens of high magnifying power is made to slide along it, in order to observe the coincidence of the images. The principle explained in the preceding paragraph may also be employed alone in plates of rock crystal, the object to be measured being substituted in place of the rectangular aperture. Or both these principles may be combined in one instrument.

MICROSCOPE.

Microscope, from μικρος, *small*, and σκοπεω, *to see*, is the name of a well known optical instrument, for seeing or magnifying minute objects.

The invention of the microscope, like that of the telescope, has been claimed for more than one individual.* Peter Borellus, in his work *De Vero Telescopii inventore*, published at the Hague in 1655, has adduced a good deal of evidence connected with the invention of the telescope and the microscope. He brings forward five different testimonies, and a letter from William Boreel, envoy from the States of Holland, which throw considerable light on the subject. Boreel was intimately acquainted with Zacharias Jansen, and had frequently been in his father's shop. He had often heard that the Jansens were the inventors of the microscope; and having been in England in 1619, he saw in the hands of his friend Cornelius Drebell, the very same microscope which Zacharius Jansen and his father had presented to Prince Maurice, and Albert, archduke of Austria. This instrument was six feet long, consisting of a tube of gilt copper, an inch in diameter, supported by thin brass pillars in the shape of dolphins, on a base of ebony, for the purpose of holding the objects to be examined. There is reason to think, that this was nothing more than a telescope converted into a compound microscope. Cornelius Drebell, therefore, who has commonly been considered as the inventor of the microscope, appears to have derived this honour from the accidental circumstance of his having exhibited the microscope made by Jansen; and as he was a favourite at the court of James VI. where he lived some time, this opinion may have proceeded, not only from his own arrogance, but from the influence of royal favour.

Viviani expressly informs us, in his life of Galileo, that this great man was led to the construction of the microscope from that of the telescope; and that, in the year 1612 he actually sent a microscope to Sigismund, King of Poland. Dissatisfied with the performance of this instrument, he appears, from his letters, to have been much occupied about 1624 in bringing it to perfection, but we have no information respecting the result of his labours.

As there is no reason to believe that the microscopes invented by Jansen consisted of two convex lenses, like those now in use, the honour of this improvement seems to be due to M. Fontana, a Neapolitan, who first described it in his work entitled *Novæ Terrestrium et Celestium Observationes, Neap.* 1646. Fontana distinctly assumes the merit of this improvement, and as no other person has laid claim to it, we agree with Montucla in allowing him the possession of this honour †

In pursuing this subject, we shall confine ourselves solely to the description of microscopes, supposing that the reader is acquainted with the principles of their construction, which fall to be explained under the article Optics. We shall treat, 1st, On Single Microscopes; 2dly, On Compound Microscopes; 3dly, On the Solar Microscope; 4thly, On the Lucernal Microscope; and, 5thly, On Microscopic Objects.

CHAP. I.

On Single Microscopes.

A *Single Microscope*, is an instrument in which only a single lens or mirror is employed for the purpose of magnifying objects. If the instrument is furnished with mirrors or lenses for illuminating the object, or with any other apparatus, however complicated, it still comes under the denomination of a single microscope.

One of the simplest of all single microscopes is a plano-convex, or a double convex lens of glass, fitted into a rim of brass furnished with a handle The object is then held in the interior focus of this lens, and appears magnified in proportion to the smallness of its focal length.

Microscopes of this kind were first successfully applied to the examination of natural objects by the celebrated Anthony Van Leewenhoek They consisted of a small double convex lens, carefully ground and polished, and inserted between two thin plates of metal, pierced with a hole smaller than the diameter of the lens, and afterwards rivetted The object was placed upon a silver point or needle, which, by the agency of screws, could be turned in all directions, and placed at any requisite distance from the lens. To this needle the objects were fixed with glue when they were solid; and when they were fluid, he put them on a thin film of mica, or brown glass, which was afterwards attached to the needle by glue In all Leewenhoek's microscopes the lenses had not a very high magnifying power; and there is reason to believe, that most of his discoveries were made more from the distinctness arising from the accurate figure and good polish of his lenses, than from the greatness of their power. Of the twenty-six microscopes which he presented to the Royal Society, only *one* had a focal length so small as $\frac{1}{20}$th of an inch, and all the rest were below *half an inch* in focal length.

Dr Hooke appears to have been the first who substituted glass globules in place of convex lenses. In

* It seems to be quite certain that the ancients were acquainted with the use of the single microscope, at least in one of its forms, as appears from the following passage in Seneca, *Literæ, quamvis minutæ et obscuræ, per vitream pilam aqua plenam, majores clarioresque cernuntur.* "Letters, though minute and obscure, appear larger and clearer through a glass bubble filled with water." *Nat Quest.* lib. i. cap 7.

† Doctor Priestley has completely misunderstood Montucla's observations on this subject, when he represents him as ascribing to Fontana the invention of compound microscopes. See Montucla's *Hist. des Math.* tom. ii. p. 239; and Priestley *On Vision*, vol. i. p. 78.

the preface to his *Micrographia*, published in 1665, he describes the method of making them. A small rod or strip of thin and good window glass is drawn out into fine threads, either by holding it in the flame of a candle, or a lamp with spirit of wine or good oil. The end of one of these threads is then held in the flame till it runs into a small drop or globule of the required size. When the globule has cooled, it is fixed upon a thin plate of brass or silver, so that the centre of it is directly over the centre of a very small hole in the metallic plate. In this way, none of the rays of light that issue from an object placed in its focus pass through the part of the globule where it is joined to the glass thread. Dr. Hooke also fixed the globules with sealing wax to the end of a stick, so that the threads stood upwards, and he ground off the ends of the threads, and polished them.

The art of making microscopic globules of glass was brought to great perfection by Father di Torre of Naples. Having formed glass globules by the method already described, he separated the ball of glass from the thread by the sharp edge of a piece of flint. When a great number of globules were made in this manner, he next proceeded to give them a complete spherical form, by melting them a second time. For this purpose, he made use of a piece of tripoli about four or five inches long, and three or four inches thick. After it had been calcined, by surrounding it with charcoal nearly red hot, and allowed to grow quite cold, several small hemispherical cavities of different diameters are made on the flat side of it, and are nicely polished and neatly rounded at the edge. The small glass globules, after being carefully cleaned, are placed in the cavities of the tripoli by a pair of delicate nippers. The extremity of the flame of a blow-pipe is then directed towards the globules, which assume a perfectly spherical form when brought to a fluid state, and never adhere to the tripoli. When the globule is cold, it is cleaned by rubbing it between two pieces of paper, and is then set in a brass cap for the purpose of trying its figure, by viewing an object through it. It sometimes happened, that in damp weather only *four* or *five* globules out of forty were fit for use. In the year 1761, four of Father di Torre's microscopes were sent in a present to the Royal Society. One of them had a diameter of $\frac{1}{36}$th of an inch, two of them a diameter of $\frac{1}{72}$d part of an inch, and the fourth a diameter of only the $\frac{1}{144}$th of an inch. Mr. Baker, who examined these globules with great care, could not make use of the smallest of them, and considered them as more curious than useful.

Another method of making glass globules, was described by Mr. Butterfield in the *Phil Trans.* for 1678. He used the flame of spirit of wine, well rectified, and burned in a lamp; but instead of cotton he employed small silver wire, doubled up and down like a skein of thread, which being wet with the spirit of wine, and made to burn in the lamp, gives a very ardent flame. Having pounded some glass, and washed it very clean, take some of it up on the point of a silver needle filed very small, and wetted. It must then be held in the flame till it be quite round, and no longer; and if the side of the glass next the needle is not melted, it may be put off, and taken up with the wetted needle on the round side, presenting the rough side to the flame till it be every where very round and smooth. When wiped with a piece of soft leather, they are ready for being placed between two plates of metal for use.

The ingenious Mr. Stephen Gray proposed to construct single microscopes with drops of water, in the following manner: "I take a thin piece of brass," says he, "filing it into the form A B, (Plate CCCLXXVII. Fig. 1,) making a small hole at A, which serves for an aperture; then holding it by the other end B, I pour a few drops of water on the table, taking up a small globule thereof with a pin, which I lay on the hole A; then removing the pin, the water will remain on the aperture, in form of a hemisphere, or a plano-convex lens. But if I have a mind to make a double convex of water, I thrust the pin, which must be less than the hole, through the hole, till the water be entered therein; then, by drawing the pin perpendicularly to the plane of the aperture, the water remains there in form of an aqueous double convex lens. Then, whatever I have a mind to view I take upon a pin, or a piece of glass, according to the nature of the object; and taking up this natural microscope by the end B, I move the object to and fro, till it be in its focus; by which means I can see objects little less distinctly than by glass microscopes, especially by candle, which I find much better than by day-light.

"But I observed, that those irregular particles which are inherent in the globules of glass were seen distinctly, and prodigiously magnified, as was easy to imagine, both from their nearness to the eye, and because they did not hinder the globules, either by day or candle light, from appearing throughout transparent, being so minute as not to be discernible, except held close to the eye, as in time of observation, and not then neither, if too near the light, but at a competent distance, they appeared as above. I knew not well how at that time to account for this strange phenomenon, that an object should be placed so far within the focus of a sphericle, as to be within the glass, and yet seen distinctly to the eye so near it; but since, by matter of fact, I found it was so, I made this inference, and concluded, that if I conveyed a small globule of water to my eye, and that there were any opaceous, or less transparent particles than the water therein, I might see them distinctly.

"Having by me a small bottle of water, which I knew to have in it some of those minute insects which Mr. Leewenhoek discovered by the help of excellent microscopes; having seen them with the common glass microscopes, and with the first aqueous, as above mentioned, I poured a few drops of this water on the table, and taking a small portion of it on a pin, I laid it on the end of a small piece of brass-wire. I continued to lay on two or three portions of water, till there was formed somewhat more than a hemispherical of water; then, keeping the wire erect, I applied it to my eye, and standing at a proper distance from the light, I saw them, and some other irregular particles, most enormously magnified; for whereas they are scarcely discernible by the glass microscopes, or the first aqueous one, within the globule they appeared not much different both in their form, nor less in magnitude than ordinary peas. They cannot well be seen by day-light, except the room be darkened, after the manner of the famous dioptrical experiment, but most distinctly by candle-light; they may be very well seen by the full moon-light. The pin sometimes takes up the water round enough to show its objects distinct." This microscope is shewn fitted up in Plate CCCLXXVII. Fig. 3.

In order to explain the magnifying effect of the globe of water upon the animalcules, or other objects placed in the inside of it, he supposes "the circle in Fig. 2, to represent a sphere of water; A an object placed in its focus, sending forth a cone of rays, two of which are AB, AB, which, coming into the water at B and B, will be refracted from their direct course, and become BD. At D they will, at their passing into the air, be again refracted into DE, DE, and so run parallel to each other, and to the axis of the sphere AECG. Now, as the angle of reflection is equal to the angle of incidence, let the rays BD, BD, be imagined to come from some point of an object placed within a sphere of water, by being reflected from the interior surface of the sphere at BB; CBD is the angle of reflection, to which making CBF equal, so will F be the place where an object, sending forth a cone of rays, two of which are FB, FB, which are reflected into the rays BD, BD, and then coming to the other side of the sphere at D and D, they are refracted into DE, DE, as before, and consequently be as fit for distinct vision, whether the object be placed at F within, or in A without, the sphere of its interior surface be considered as a concave reflecting speculum." *Phil. Trans.* 1696, No. 221, p. 280.

This microscope is evidently one which operates both by reflection and refraction. The anterior part is a concave mirror, by which all objects placed between its surface and its focus are magnified; and, as Dr. Smith has shewn, it magnifies objects $3\frac{1}{3}$ times more than if they were presented to it in the usual manner. See Smith's *Optics*, Vol. II. p. 395.

Mr. Gray suggested also a single reflecting microscope, founded on a similar principle. Let A, (Plate CCCLXXVII. Fig. 4.) represent a small flat ring of brass, whose mean diameter does not exceed $\frac{4}{10}$ths of an inch, and which is about $\frac{1}{30}$th of an inch thick. Take a small globule of quicksilver, and dissolve it in a few drops of aquafortis, to which add 10 parts of common water; dip the end of a stick in this liquor, and rub with it the inner circle of the ring A, so as to give it a mercurial tincture. After it is wiped dry, and laid upon the table, pour a drop of quicksilver within it, which being pressed gently with the ball of the finger, will adhere to the ring; and when it is cleansed with a hare's foot, it will form a convex speculum. Take up the ring and speculum, carrying it horizontal, and lay it on the brims of the hollow cylinder B, and the mercury will now become a concave reflecting speculum, which may be used as a reflecting microscope. *Phil. Trans.* 1697, No. 228, p. 539.

Single microscopes, of a very simple kind, were constructed by Dr. Brewster, by taking up drops of very pure turpentine varnish, and allowing them to fall on a plate of thin and parallel glass. In this way he formed plano-convex lenses of any focal length; and, by dropping the varnish on both sides, he formed double convex lenses, with their convexities in any required ratio. The focal length of these lenses increase a little after they are formed, on the upper side of the glass, but diminish if they are formed on the lower side of it; and if they are preserved from dust, they will last a long time. Dr. Brewster employed these fluid lenses as the object glasses of compound microscopes.

A very ingenious method of forming single microscopes of glass has been recently proposed and executed by Mr. Sivright of Meggetland. Take a piece of platinum leaf, about the thickness of tinfoil, and make two or three circular holes in it, from one-twentieth to one-tenth of an inch in diameter, and at the distance of about half an inch from each other. In the holes put pieces of glass, which will stick in them without falling through, and which are thick enough to fill the apertures. When the glass is melted at the flame of a candle with the blow-pipe, it forms a lens which adheres strongly to the metal, and the lens is therefore formed and set at the same time. The pieces of glass used for this purpose should have no mark of a diamond or file upon them, as the mark always remains, however strongly they are heated with the blow-pipe. The lenses which were made larger than one-tenth of an inch were not so good as the rest, and the best were even of a smaller size than one-tenth. As the lenses thus formed sometimes contain air bubbles, the best way is to make several, and to select those which are freest from imperfections. An eye or loop, made by bending the extremity of a platinum wire, may be used instead of the platinum leaf. The reason of using platinum is, that the glass is more easily and more perfectly melted in this than in other metals, which may perhaps arise from its being a bad conductor of heat, and from its preserving its brightness. As platinum does not oxidate, the glass adheres better to the edges of the holes, and it may be used very thin, as it does not melt with the heat necessary for the complete fusion of the glass.

Mr. Sivright has likewise succeeded in forming plano-convex lenses by means of fusion. Having laid a fragment of glass upon a flat and perfectly polished natural surface of topaz, which is easily obtained by cleavage, he exposes the whole to an intense heat. The upper surface of the glass assumes a spherical figure, in virtue of the mutual attraction of its parts, and the lower surface becomes perfectly flat, and highly polished, from its contact with the polished plate of topaz. See *Edinburgh Philosoph. Journal*, vol. I. p. 81.

A new kind of single microscopes, which possess particular properties, have been lately constructed by Dr. Brewster. They consist of plano-convex or double-convex lenses of a hemispherical or spherical form, which may be converted into single microscopes, having a much greater magnifying power than when they are used in the ordinary way. Let ABC, (Plate CCCLXXVII. Fig. 5.) for example, be a hemispherical plano-convex lens, which may be used as a single microscope, either by presenting the side A or the side D to the object. But if we place the object at *mn*, and looking in at F, examine it after reflexion from the surface BC, we shall have an effect the same as if we had placed the two lenses A *a* B *d*, A *a c d*, with their plane sides AB, AC together, or rather of a double-convex lens similar to the two united. As the light is incident on BDC at an angle of 45°, it will suffer total reflexion, and not a ray of it will be lost. The spherical aberration of the lens used in this way, is to its spherical aberration used in the common way, as 97 to 117. A hemispherical lens employed in this manner, and having the line BC inclined 45° to the axis of telescope, will form the best possible diagonal eye-piece. When the segment ABC is less or greater than a hemisphere, the same effects will be produced. With a double-convex lens, as shewn in Plate CCCLXXVII. Fig. 6. a very high degree of magnifying power is obtained by looking in at E, and we have the effect of a compound microscope, consisting of an object-lens AC, a concave mirror CBD, and an eye-glass AC. The perfection of the image will, in this case, increase, as the incident or reflected rays approach to DA. In these, as well as in all other microscopes, the object should be illuminated from one point, such as a single candle or luminous aperture. See the *Edinburgh Philosophical Journal*, No. V.

A very great improvement on the microscope has been lately suggested by Dr. Wollaston, under the name of the Periscopic Microscope.

"The great desideratum," says he, "in employing high magnifiers, is sufficiency of light; and it is accordingly expedient to make the aperture of the little lens as large as is consistent with distinct vision. But if the object to be viewed is of such magnitude as to appear under an angle of several degrees on each side of the centre, the requisite distinctness cannot be given to the whole surface by a common lens, in consequence of the confusion occasioned by oblique incidence of the lateral rays, excepting by means of a very small aperture, and proportionable diminution of light. In order to remedy this inconvenience, I conceived that the perforated metal which limits the aperture of the lens might be placed with advantage in its centre, and accordingly I procured two plano-convex lenses, ground to the same radius, and applying their plane surface on opposite sides of the same aperture, in a thin piece of metal, (as is represented by a section, Plate CCCLXXVII. Fig. 7,) I produced the desired effect; having virtually a double-convex lens, so contrived that the passage of oblique pencils was at right angles with its surface, as well as the central pencil. With a lens so constructed, perforation that appeared to give the most perfect distinctness was about one-fifth part of the focal length in diameter; and when such an aperture is well centered, the visible field is at least as much as 20 degrees in diameter. It is true that a portion of light is lost by doubling the number of surfaces; but this is more than compensated by the greater aperture which, under these circumstances, is compatible with distinct vision." *Phil. Trans.* 1812, p. 375.

It is obvious from the last paragraph of this quotation, tbat the idea had not occurred to Dr. Wollaston of filling up the central aperture with a fluid of the same refractive power as the glass of which the two lenses are composed. This improvement, which was practised by Dr. Brewster, (as shewn in Plate CCCLXXVII. Fig. 8.) removes entirely the loss of light arising from doubling the surfaces. The same thing may be done in a still more perfect manner, as in Fig. 9. as proposed by the same author, where a groove is cut round the globule or spherical lens, by the wheel of a seal engraver. By this means the doubling of the surfaces is avoided, and the most perfect centering obtained. As it is much more easy to grind two double convex lenses, than two plano-convex ones, as shewn in Fig. 7. we might avail ourselves of this circumstance in the construction, to adopt the form shewn in Fig. 10. and render the microscope achromatic, by introducing a concave fluid lens of a different refractive and dispersive power, as shewn in Fig. 10. which, independent of the correction of colour, is a simpler construction than that shewn in Fig. 7.

Following out the principles which we have here explained, Dr. Brewster has proposed a miscroscope, constructed as in Plate CCCLXXVII. Fig. 11. where AB, CD, are two double convex lenses, so constructed that the concave lenticular space ABDC, would, when filled with a fluid of different dispersive and refractive power, correct the aberration of refrangibility. A convex speculum of steel or polished silver, perforated with an aperture *c f*, has its anterior surface P *e* Q highly polished, and either attached by a transparent cement or not to the lens AB. The aperture *e f* being filled with the proper fluid, and CD cemented to the posterior part of the steel, the lens is ready for use. The curvature of the reflector P *e* Q, is such as to reflect parallel rays incident on AB, upon the object to be examined, being converted into a concave speculum by the lens placed before it.

By this means, we obtain a lens possessing very unusual properties, and capable of affording the most perfect view of microscopic objects.*

Having thus described the various kinds of single microscopes which have been used, we shall now give an account of the improvements which have been made in adapting them to the examination of minute objects.

The first and most important of these improvements was made about the year 1739, by Dr. Lieberkhun. He placed the single lens on the centre of a convex speculum, made of silver, and highly polished, and having its concavity so adjusted to the focal length of the lens, that the light of a candle or of the sky could be thrown upon the side of the object next the observer. When the single lens is of a small focal length, the light is kept from falling upon the object, not only by its proximity to the lens, but by the body of the observer, so that it becomes impossible to examine microscopic objects, particularly opaque ones, with any satisfaction. Dr. Lieberkhun adapted a microscope to every object of any particular interest. At the eye end of a short brass tube, he placed the convave speculum, carrying the single lens in its centre. The object was placed in the middle of the tube, and had a contrivance for adjusting it to distinct vision, and at the object end of the tube, there was a plano-convex lens for concentrating the light which fell upon the concave speculum. Some of these microscopes are said to be deposited in the British Museum.

We shall now proceed to descibe some of the best single microscopes, as fitted up for use. The most important of these are:

1. The common flower and insect microscope.
2. The small microscope, with apparatus for opaque objects.
3. Withering's botanical microscope.
4. The pocket botanical and universal microscope.
5. Lyonet's anatomical microscope.
9. Wilson's pocket microscope.
7. Ellis's aquatic microscope.
8. Barrel microscope.

I. *Description of the Common Flower and Insect Microscope.*

This microscope is one of the most simple, and the most convenient, and is peculiarly fitted for being put into the hands of young persons, who are not capable of managing a more complicated apparatus. Above

* See the *Edinburgh Philosophical Journal*, No. V. or Vol. III. Part I.

the handle H, (Plate CCCLXXVII. Fig. 12) is fixed the arm LM, which carries a lens at L, which may be either used alone, when a small power is wanted, or in conjunction with another lens *a*, which screws on the ring at L, when a higher power is needed. A horizontal grooved arm MN, also fixed to the handle, carries the pincers or forceps OP, which hold the object O, and this object can be placed at different distances from the lens L, so as to obtain distinct vision by sliding the forceps along the groove in MN, and fixing it at the proper position by means of the button or nut B.

II. *Description of the Microscope for Opaque Objects.*

This microscope, which is a little more complicated than the preceding, is represented in Plate CCCLXXVII. Fig. 13. The ivory handle P is fixed in the arm A, through which passes a screw B, having its other end fastened to the moveable arm C. By turning the nut D upon the head of the screw B, the arms A and C may be either separated or brought together, being kept asunder by a steel spring E. The piece GH, consisting of a pointed steel wire G, and of a pair of pliers H, passes through a spring socket moving on a rivet. The object may be either fixed on the point G, or taken up by the pliers, and may be turned round in any direction, by the joint at F, or by sliding the piece GH through the spring socket. A ring of brass I with a female screw is fixed on an upright piece of brass turning on a pivot, in order that it may be set at a proper distance when the smallest magnifiers are employed. A concave speculum K, of polished silver, has a lens placed in its centre, according to the method of Dr. Lieberkhun, already described; and there are generally four of these of different concavities, with four glasses of different magnifying powers. A round object-plate, as shown at M, has one side white and the other black, all dark objects being placed upon the white side, and all light objects upon the black side, in order to render them more visible by contrast. A steel spring N, moving round the centre, can be turned down on each side, for the purpose of pressing the object to the black or white ground. A hollow pipe proceeds from the object-plate, in order to screw it on the point of the needle G. A small box O of brass, with a glass on each side, for the purpose of enclosing any living object for examination, has likewise a pipe for the purpose of screwing it upon the end of the needle FG. A pair of pliers for taking up any object is shown at Q, and a soft hair brush at R.

In using this microscope, the speculum KL, with its accompanying magnifier, must be screwed into the ring I. The object is then to be placed according to its nature on the needle G, in the pliers H, or on the black or white side of the object-plate M, or between the glass plates of the box O; and having taken the instrument by the handle P, the eye looks through the magnifying lens screwed on at I, and by means of the nut D, and the motion of the needle, the object may be turned about, raised or depressed, or made to approach to or recede from the lens, till it is placed in the true anterior focus of the lens, where the light will be reflected upon it by the concave speculum.

III. *Withering's Botanical Microscope.*

The botanical microscope used by Dr. Withering, is shown in Plate CCCLXXVII. Fig. 14. where A, B, C, are three parallel brass plates. Two wires D and E are rivetted into the upper and lower plates A and C, and the middle plate B is moveable along these wires by two little sockets fixed to it. The two upper plates contain each a magnifying lens of different focal lengths, one of which keeps in their places the sharp point F, the small knife K, and the pliers P.

Before using this microscope, we must unscrew the upper lens, and take out the point, the knife, and the pliers; and having replaced the lens by screwing it on again, the object is placed on the stage, and moved up or down till it is seen distinctly.

IV. *Pocket Botanical and Universal Microscope.*

This instrument, which is superior to Dr. Withering's, is represented in Plate CCCLXXVII. Fig. 15. A small arm AB carries three lenses, two of which are fixed to the upper part at B, and the other to the lower part at C; and as these three lenses may be either used separately or combined, they afford us seven different magnifying powers. A square pillar AK supports the arm AB. The lower end of this pillar fits into the socket E of the base FG. The stage DL, carrying the pliers M and a sharp point N, constructed as formerly described, is made to slide up and down the pillar IK. A reflecting mirror H, moving round a horizontal and vertical axis, is fixed into the base FG, and reflects light through the object. In using this microscope, the objects are placed on the stage L; or, if they are put into ivory sliders, these sliders pass under the stage L. The light is then thrown upon the object by the mirror H, and distinct vision obtained by the motion of the stage. Other objects may be fixed in the pliers M, N, and used as already described.

The apparatus accompanying this instrument consists of three ivory sliders, a pair of nippers, a flat glass, and a concave lens, all of which are fitted to the stage L. By taking out the pin E, the pillar IK may be turned half round, and the base FG used as a handle. The stage DL, instead of being moved by the hand, is frequently raised and depressed by an adjusting screw.

V. *Lyonet's Anatomical Microscope.*

The microscope represented in Plate CCCLXXVII. Fig. 16, was employed by M. Lyonet in his microscopical dissection of the caterpillar of the goat moth. It consists of an anatomical table AB, supported by a pillar ON, screwed into the mahogany box DC. In the table AB, which is prevented from turning round by two steady pins, is an aperture G, exactly over the mirror EF, for reflecting light on the object. A flat or concave glass is placed on the aperture G. for receiving the objects to be dissected. An arm RXZ, composed of several balls and sockets, by which it has an universal motion, is fixed to the table AB by means of the screw H. The last arm IZ carries a female screw for receiving a magnifying lens, as shown at Z. The lens is generally adjusted to distinct vision of the object by the hand, though a small motion may be given to it by the screw at H. Another chain of balls and sockets is sometimes used for holding an illuminating lens. The mirror EF can also be taken from its place at K, and fixed by a clamp to any part of the table AB.

In using the dissecting table, the instrument should stand upon a firm table, the left side of the observer being near a light window, and the side DL towards his breast. The observations should be made with the left eye; and in dissecting, the two elbows should be supported on the table which holds the microscope, the hands resting against the board AB, to give it greater steadiness. See Lyonet's *Traité Anatomique de la Chenille, &c.*

VI. *Wilson's Pocket Microscope.*

The microscope invented by Mr. Wilson has been long in use. The body of it is represented by AB, (Plate CCCLXXVII. Fig. 17.) and is made either of brass, silver, or ivory. Another tube, with a long fine-threaded small screw upon its circumference, screws unto the body AB. A convex lens D is screwed into the end of the tube CC, and its area may be increased or diminished by placing upon it one or other of the two concave apertures of thin brass, which are necessary when the highest magnifiers are employed. Two thin plates of brass are shown at E, within the body of the microscope; and one of them is bent into an arched or semicylindrical cavity, shown in the figure, for the purpose of receiving a tube of glass. At the eye-end G of the microscope is a female screw for receiving the different magnifiers. A spiral steel spring H, abutting with one extremity against the end G and with the other against the plate of brass E, serves to keep the plates in a proper position, and to act against the long screw C. The microscope is held by the ivory handle I. *Seven* different magnifying glasses, *six* of which are set in cells, as shown at K, are numbered from 1 to 6, the least numbers being the highest magnifiers. The *seventh*, or least magnifier, is set in a small tube, in order that it may be held in the hand for viewing any large object. The objects are held in an ivory slider M. Six sliders like this of ivory, and one of brass, generally accompanying the instrument. A brass slider, not represented in the figure, is sometimes added, for the purpose of confining any small object, in order that it may be examined without being crushed. A pair of forceps and a hair-brush are used, as shown at R and Q, Fig. 13. A glass tube, for holding living objects, such as frogs, fishes, &c. is shown at P.

In order to use this microscope, the slider containing the object is thrust between the two flat brass plates EF, care being taken to put the face of the slider where the brass rings are farthest from the eye. The magnifying glass intended for use must then be screwed on at G; and while the eye looks through it against the sky, or the light employed, the long screw CC is turned till the objects in the slider are brought into the anterior focus of the lens, when a distinct view of them will be obtained. By moving the sliders between the plates at E, different parts of the same object may be brought into view, or different objects in the slider; but at every motion of the slider, vision should be made distinct by a new adjustment with the screw.

This instrument is sometimes placed upon a stand, with a reflecting mirror, as shown in Fig. 15. In order to see opaque objects with it in this case, an arm QR, Fig. 17. is screwed into the body of the microscope at G. The proper magnifier is next screwed into the hole at R, and putting the concave speculum S on the outside of the ring R, the object is held upon the forceps, or point of T, whose wire slips into a small hole, shown at *u*, in the body of the microscope. The arm R is then turned till the magnifier is brought over the object, and distinct vision is obtained by turning the screw C as formerly.

VII. *Ellis's Aquatic Microscope.*

This microscope differs from the one shown in Fig. 15 so little, that it is unnecessary to engrave it. Instead of the stage DL moving, the arm AB containing the magnifiers slides up and down. The magnifiers are each set in the centre of a concave silver speculum. This microscope was employed by Ellis in his observations on Corallines and the Zoophytes. See Ellis's *Essay on the Natural History of Corallines*, and his *Natural History of many curious and uncommon Zoophytes.*

VIII. *Barrelled Microscopes.*

Single microscopes for opaque objects are sometimes conveniently fitted up with a barrel or cylinder, on the circumference of which are placed the objects to be examined. By turning the barrel round its axis, the different objects are brought under the magnifiers, and by a lateral motion of the barrel, other objects may be brought into view.

IX. *On the magnifying power of Single Microscopes.*

The magnifying power of single microscopes increases with the smallness of their focal length, and may be easily found, by dividing the distance at which the eye sees objects distinctly by the focal length of the lens or globule. This distance varies in different persons, and has generally been assumed at 7 or 8 inches. It is obvious, however, that very minute microscopic objects, when examined with an eye of the ordinary focal length, are always viewed at a less distance than 7 or 8 inches, in order to obtain the best possible view of them; and, therefore, it is this distance that should be divided by the focal length, in order to obtain the magnifying power of the instrument, or the real measure of the help which we derive from it. This distance will be found not to exceed *five inches*; and upon this supposition we have computed the following Table, shewing the magnifying power of single microscopes from $\frac{1}{100}$th of an inch to 1 inch.

Table of the Magnifying Power of Small Convex Lenses, or Single Microscopes, the Distance at which the Eye sees distinctly being 5 Inches.

Focal Distance of the Lens, or Microscope.		Number of Times, that the *Diameter* of an Object is magnified.	Number of Times that the *Surface* of an Object is magnified.	Number of Times that the *Cube* of an Object is magnified.
100dths of an Inch.		Times. Dec. of a Time.	Times.	Times.
1	100	5.00	25	125
$\frac{3}{4}$	75	6.67	44	297
$\frac{1}{2}$	50	10.00	100	1000
$\frac{2}{5}$	40	12 50	156	1953
$\frac{3}{10}$	30	16.67	278	4632
$\frac{2}{10}$	20	25.00	625	15625
	19	26.32	693	18233
	18	27.78	772	21439
	17	29 41	865	25438
	16	31.25	977	30510
	15	33.33	1111	37026
	14	35.71	1275	43538
	13	38.48	1481	56978
	12	41.67	1736	72355
	11	45 55	2075	94507
$\frac{1}{10}$	10	50.00	2500	125000
	9	55 55	3086	171416
	8	62 50	3906	244141
	7	71.43	5102	364453
	6	83.33	6944	578634
$\frac{1}{20}$	5	100.00	10000	1000000
$\frac{1}{25}$	4	125.00	15625	1953125
	3	166.67	27779	4629907
$\frac{1}{50}$	2	250.00	62500	15625000
	1	500 00	250000	125000000

The *first* column of the Table shows the focal length of the lens, or globule, in 100dths of an inch. The *second* column shows the number of times that it is magnified in diameter, or in one dimension. The *third* column shows the number of times that the surface is magnified; and the *fourth*, the number of times that the cube of an object is magnified.

As microscopic objects, however, are never mathematical lines, and as their solidity, or their magnitude in three dimensions, cannot be rendered visible by a microscope, we consider the *second* column as containing the *real magnifying power of the microscope*, although opticians have hitherto adopted the numbers in the first column, from an erroneous analogy with the telescope.

CHAP. II.

On Compound Microscopes.

We have no means of ascertaining, from the descriptions of Jansen's microscope, the particular combination of lenses which he employed. It seems more than probable, that the microscopes used by him and Galileo consisted of a convex object lens, and a concave eye-glass, and were nothing more than a short telescope converted into a microscope by lengthening its tube.

In 1646, Fontana tried two convex lenses; and in all the microscopes which were subsequently used, three or more convex lenses were employed, as in the finest instruments which are now in use. Dr. Hooke, in the Preface to his *Micographia*, gives an account of the microscope which he employed. It was about seven inches long, and three inches in diameter, and consisted of four drawing tubes, by which it could be lengthened or shortened at pleasure. It had three glasses, viz. a small object-glass, a middle glass, and an eye-glass. When he wished to have a large field, or to see a great part of the object an once, he used all the three lenses—the middle lense converging upon the eye-glass pencils, which, by their divergency, could not have fallen upon it. But when he wished to examine any individual part with the greatest distinctness, he removed the middle glass, and used only the other two glasses.

A description of the microscope of Eustachio Divini, was laid before the Royal Society in 1668. It consisted of an object-glass, a middle-glass, and *two eye-glasses*, which are plano-convex, and placed so as to touch one another in the middle of the convex surfaces. The purpose of his construction was to shew the objects flat, and not crooked, and to take in a large field, at the same time that it had a high magnifying power. It was about $16\frac{1}{2}$ inches high, and adjusted at four different lengths. In the first, which is the best, it shews lines 41 times larger than they appear to the naked eye; in the second, 90 times; in the third, 111 times; and in the fourth, 143 times. The diameter of the field, or the subtense of the visual angle, measured upon the object plate, in the *first* length, was 8 inches 7 lines; in the *second*, 12 inches 4 lines; in the *third*, 13 inches; and in the *fourth*, a little more than 16 inches. The tube was as large as a man's leg, and the eye-glasses like the palm of the hand. See *Phil. Trans.* 1668. No. 42. p. 842.

Philip Bonnani, in a work entitled *Observationes circa Viventia, quæ in rebus non viventibus reperiuntur, &c.* 1791, published an account of two compound microscopes which he used. One of these was composed of an eye-glass, a middle-glass, and an object-glass, mounted in a cylindrical tube placed horizontally. Behind the stage was a small tube, with a convex lens at each end, and a lamp beyond it, whose light was concentrated by the lenses in the tube, and thrown upon the object to be examined. The instrument possessed various adjustments, and was regulated by a rack and pinion.

Sir Isaac Newton seems to have been the first person who suggested the use of a reflecting microscope. He placed the objects before a concave speculum, so that an enlarged image of them was formed at a greater distance. This image being viewed with a convex eye-glass, was again magnified, and appeared very distinct. The great defect of this instrument arose from its being inapplicable to opaque objects, in consequence of the objects being placed between the object speculum and the eye-glass. See *Phil. Trans.* 1672, No. 10. p. 3075, and the Appendix to Gregory's *Elements of Optics*.

Another form of the reflecting microscope was suggested by Dr. Robert Barker, in the year 1736. It was nothing more than the Gregorian telescope converted into a microscope, merely by lengthing the tube, and therefore requires no particular description. There can be no doubt that it would give very distinct images, and has the advantage of allowing the light to fall freely upon the object, which is placed at a distance of from 9 to 24 inches beyond the tube. See *Phil. Trans.* 1736, Vol. 39. No. 442. p. 259.

The next compound microscope was invented by Dr.

Robert Smith, Professor of Experimental philosophy at Cambridge. Having had occasion to examine the principles of Sir Isaac Newton's reflecting microscope, he constructed one of them, in which the focal distance of the speculum was $2\frac{1}{3}$ inches. He "found that the colours of objects appeared much more beautiful and natural than in doubly refracting microscopes of the best sort, their proper colours being free from the mixture of other colours arising in refracting microscopes, from the different refrangibility of rays." Smith's *Optics*, Vol. I. p. 279. He found also that objects appeared sufficiently bright, and very distinct, when the reflecting microscope had the following dimensions:

Focal length of the speculum . .	$2\frac{1}{3}$ inches.
Diameter of the speculum . . .	1
Focal length of the plano-convex eye-glass	$2\frac{1}{3}$
Ratio of the distance of the object from the focus of the speculum, to the focal distance of the speculum . . .	1 to 14

Having found that, in order to produce a high magnifying power with this reflecting microscope, it was necessary to have the speculum very concave, and therefore very small, he set about contriving a microscope with two reflecting spherical surfaces of any size, so proportioned to each other that the aberration of the rays, caused by the first reflection, should be perfectly corrected by the second, and, consequently, that the last image of the object from which the rays diverge upon the eye-glass, shall be perfectly free from aberration.

One of Dr. Smith's microscopes is shewn in Plate CCCLXXVII. Fig. 18. where AA is a concave spherical speculum, and CC a convex spherical speculum, having its polished convex surface inwards. The rays from an object *o* placed in the slider *mn*, will be reflected from the concave speculum AA upon the concave CC, and will have a distinct and magnified image of it formed before the convex eye-glass E, by which it will be magnified still more. This instrument, in short, is nothing more than the Cassegrainian telescope converted into a microscope, with this difference only, that, in the telescope, distinct vision is obtained by moving the convex mirror, whereas, in the microscope, it is obtained by a motion of the eye-glass. Dr. Smith constructed one of these microscopes, which he found to perform "nearly as well, in all respects, as the very best refracting microscopes;" and the writer of this article has one of them now before him, which performs wonderfully well, though both the specula have their polish considerably injured. The following are the dimensions, &c. of Dr. Smith's reflecting microscope as given by himself:

Focal length of both specula . .	1 0000
Distance of the centres of both specula	1.6558
Distance of the image from the centre of the concave speculum . .	1.1337
Focal length of the eye-glass . .	.0.1407
Distance of the eye behind the eye-glass	0.1479
Diameter of the eye-hole . . .	0.0190
Distance of the object from the centre of the convex speculum . .	0.0626
Length of the concave speculum .	15° 47
Arch of the convex speculum . .	4° 50′ 49″
Distance of the stop *s* from the object	0.4545
Diameter of the stop *s* . . .	0.038
Diameter of the hole in the concave speculum	0.143
Diameter of the hole in the convex speculum	0 049
Magnifying power, the focal length, &c. of the eye being 8 inches . . .	300 times.

The stop *s* is placed behind the convex speculum, in order to prevent the direct rays from the object, which would pass unreflected through the openings in both specula, and fall upon the eye-glass, from mixing with the rays regularly reflected by the specula, and forming the magnified image upon the retina. See Smith's *Optics*, Vol. II. Remarks, p. 94.

The next microscopes which excited any notice, were those of M. Delebarre of the Hague, who began to construct them in 1771. Montucla saw them when he travelled in Holland in 1773, and induced Delebarre to go to Paris, where he was well received, and where he sold many of his instruments, each of which cost about 15*l*.* M. M. Montigny, Leroi, and Brisson, submitted to the Academy, on the 21st of June, 1777, a most flattering report of their performance, and Montucla has given a very full account of them in his History of Mathematics. We have read these eulogiums and descriptions with great attention, and are obliged to acknowledge, that we cannot find in the microscope of Delebarre any improvement of the least importance which had not been known and adopted by the London opticians. The only point of difference that we can observe is, that of changing the eye-glasses, and of combining six lenses at once, which Montucla seems to lay considerable stress upon, because Euler, in his paper *De Novo Microscopiorum genere*, published in the memoirs of St. Petersburgh for 1766 and 1767, had pointed out certain theoretical advantages which he conceived would be found in microscopes with six lenses. Such a combination of lenses, however, has been exploded, and we do not scruple to say, that there is no eminent optician in Europe who would construct a microscope in such a manner, unless the lenses were arranged, as in some modern eye-pieces, so as to correct the chromatic aberration.

M. Æpinus of St. Petersburgh proposed in the year 1784, (*Nov. Act. Petrop.* 1784,) to construct microscopes with large apertures of considerable length, *with Achromatic object-glasses*. The great object of this construction was to permit light to be easily thrown upon the object; and in order to put his idea to the test of experiment, he constructed a microscope, in which the aperture of the object lens was about 1 inch; the distance of the object from the object-glass 7 inches, and the length of the whole instrument a little less than three feet. The magnifying power was from 60 to 70, and therefore the focal length of the eye-glass must have been about $\frac{1}{2}$ an inch, so as to magnify by itself 12 or 13 times. This instrument is said to have given great satisfaction. The same idea had occurred long before to our countryman Benjamin Martin, who, in his description and use of a polydynamic microscope, has shewn that the achromatic perspective may be easily applied for this purpose.

Various improvements were made upon the microscope by Mr. Cuff, Mr. Benjamin Martin, Mr. Adams,

* Delebarre described his microscope in a memoir which was read at the Academy of Sciences in 1777, and in a separate pamphlet, entitled *Description et l'Usage du Microscope Universel.*

and other opticians; but as they relate principally to the method of fitting them up, and of rendering them more commodious and universal in their application, we cannot enter into any detailed account of their respective improvements, which will be better seen in the account of the instruments themselves.

Having thus given a short account of the history of the compound microscope, we shall now describe some of the most interesting forms in which it has been fitted up.

I. *Cuff's Double Constructed Microscope.*

This instrument is represented in Plate CCCLXXVII. Fig. 19, where ABC is the body of the microscope, having an eye-glass at A, an amplifying lens at B, and a magnifier screwed on at C, and shewn separately at Q. The body of the microscope is supported by the arm DE, fixed on the sliding bar F. The principal pillar *a b* is fixed on the box *b e*, and the brass foot *d* is screwed to the mahogany pedestal XY, having a drawer to contain all the apparatus. The bar F is tightened by a milled headed screw O, when the adjusting screw *c g* is used. The objects are laid upon the stage *p q*, with a hole *n* in its centre, and the light thrown upon them by the concave mirror G.

The following are the different parts of the apparatus which accompany the microscope:

- H a convex lens for concentrating the rays of the sun upon the objects.
- L a cylindrical tube open at each side, and having a concave silver speculum screwed to the lower end *h*.
- P the tube for holding the lens K, with an inner tube, which is forced upwards with a spiral spring. The sliders are thrust between the plates *h* and *i*. The lower end of P goes into the hole *n* in the stage. The hollow part at *k* is intended to receive a glass tube N.
- R is a brass cone, which is occasionally put in the bottom of the cylinder P to intercept the light.
- S is a box, with a concave and a flat glass for confining small living insects. It is placed upon the hole *n*.
- T is a flat glass to lay objects upon, and *u* a concave one for fluids.
- O is a pair of pliers and a sharp point; and Z a brush, as formerly described.
- W is a round ivory box, for holding circular pieces of mica, and rings for the sliders.
- V is a small ivory cylinder, which goes upon the pointed end of the steel wire O.
- M a fish-pan for holding small fishes, in order to view the circulation of the blood. The tail is spread across the oblong hole at the small end *k*, and tied firmly by a ribbon fixed to it. The knob *l* is to be put through the slit *m* made in the stage, and the tail may be brought below the end C of the microscope.
- X is a wire, by which the glass tubes are cleaned.

In using this microscope, screw the proper magnifier to the end C, place the tube P in the hole *n*, and slip one of the ivory sliders between the plates *h* and *i*. Make the upper edge of the bar DE coincide with the division, having the same number with the magnifier used, and fix it firmly by the nut O. Light being thrown upon the object by the mirror G, apply the eye to the upper end of the microscope, and obtain distinct vision by means of the adjusting screw *e g*.

When the objects are opaque, remove the tube P, and having placed the object on a flat glass *u* under C, or upon one end of the jointed pliers *o p*, screw the concave silver speculum to the end of the cylinder L, and slide this cylinder on the lower part EC of the tube, so that the upper edge of L may coincide with the same number as the number of the magnifier employed. Reflect the light employed from the mirror G upon the speculum *h*, and it will be again reflected from the speculum upon the side of the opaque object next the eye.

II. *Universal Compound Microscope.*

One of the most complete and commodious compound microscopes is represented in Plate CCCLXXVII. Fig. 20. where AB is the body, the eye-glasses being contained in an inner sliding tube, by which their distance from the glass at B can be increased or diminished, and the magnifying power of the instrument altered. The body AB is attached by a screw to the arm CD, which may be moved through a square socket over the object. The stage NIS moves up and down the square bar EF by means of the rack and pinion M; and this bar, with all its accompanying apparatus, moves round a joint at the top of the great pillar V, supported upon the three feet G, G, H. By the aid of this joint, the microscope may be put into a horizontal, a vertical, or an oblique direction. At the stage NIS is a sliding brass spring N for confining slips of glass, or large sliders, when the microscope is to be used out of the horizontal position. The lens U is intended to concentrate or modify the light reflected from the mirror G, and it may be adjusted to a proper distance by means of two small screws, one of which is seen at *u*. In candle light this lens is of great use, and it may be turned aside on a joint when it is not required. Six magnifying lenses are set in a brass wheel, screwed in a circular box P. The wheel may be moved round its centre by the action of the finger on its milled rim, and it stops by a click the instant that any of the magnifiers comes into its exact position in the axis of the other lenses. The lenses are numbered from one to six, and the proper number appears in a small opening made in the upper side of the box P. This box screws into the arm CD, and may be taken off when required. If we unscrew the body AB, the intsrument becomes a single microscope by looking directly through any of the lenses in the wheel. The mirror O may be moved up or down the bar EF, by pushing against the screw at *r*. In addition to the apparatus already described, as belonging to single microscopes and to Cuff's compound microscope, the following may be enumerated. A moveable stage W, which is applied to the hole S of the stage by the pin *a*, and has thus a horizontal motion under the field of view. A very deep concave lens *r* is fitted to the large hole of this stage, and also the concave and plane glasses *s* and *o*, while to the small holes *x*, *x*, a black and white piece of ivory *w* is fitted for opaque objects, and a concave and plane glass similar to *o* and *s*. The arm CD is sometimes furnished with rack work, to turn the pinion above, so as to move the magnifiers in the most accurate manner over the objects; and the stage NIS is sometimes jointed, in order to turn by a screw and teeth in a horizontal direction. In using this microscope, the slider-holder K, containing a slider of objects, is placed in the stage NIS, and the arm CD is moved in its socket, till a mark on the side is brought to the edge of the socket. The arm is then turned, till the magnifier is directly over the object, the eye being then placed at the upper end of the tube AB, and the light reflected strongly up into it from the mirror O. The pinion M is then turned to the right or left till the object is seen in the most distinct manner. When the objects are opaque, the slider-holder K is removed, and either the concave glass, or the jointed pliers, are placed on the stage. The concave silver speculum *e* is then screwed into the arm *a*, which is placed on the stage, with the cylindrical part passing through the hole 1; and the light being reflected upon the speculum from the mirror O, it will be strongly condensed by it, and thrown upon the opaque object.

If we consider the construction of the different compound microscopes which have been described, it will be obvious, that a great deal must depend on the accuracy with which the axes of the small magnifying lenses coincide with the axis of the instrument, or that of the eye-glasses. The difficulty of effecting such a coincidence is very great, and we believe is in a great measure overlooked. We conceive, therefore, that the tube which holds the magnifying lenses should have an universal motion, so that, by means of screws, the axis of the lenses could be brought into perfect coincidence wih the axis of the eye-glasses.

III. *Amici's Reflecting Microscope.*

We have already seen that the reflecting microscope of Dr. Barker was nothing more than the Gregorian telescope, with its tube lengthened so as to permit it to act as a microscope; and that the reflecting microscope of Dr. Smith was the Cassegrainian telescope fitted up in a similar manner. The new reflecting microscope constructed by Professor Amici of Modena, and with which he has made several important discoveries, is in like manner the Newtonian telescope converted into a microscope.

It consists of a horizontal brass tube ABCD, Plate CCCLXXVII. 12 inches long, and $1\frac{1}{10}$ of an inch in diameter. A concave metallic speculum AB, having its reflecting surface a portion of an ellipsoid, whose foci are F and *f*, is placed at one end of the tube; the distance AF being $2\frac{6}{10}$ inches, and A*f* 12 inches. A small arm *rs* within the tube, carries a plane speculum of an oval form, placed at the distance of $1\frac{5}{10}$ inches from AB, supported by an oblique section of an metallic cylinder, $\frac{5}{10}$ of an inch in diameter, and inclined 45° to the axis F*f* The object is placed below the tube at MN, and as far before the mirror *s* as the focus F of AB is behind it; and it is supported by a moveable object-bearer attached to the pillar below it. The diameter of the tube ABCD is about $1\frac{1}{10}$ inches, and the thickness of its metal $\frac{1}{20}$th. The object is always placed at the distance of half an inch from the edge of the tube, and may therefore be illuminated by a convex lens, attached in the usual way to the stage or object-bearer. A large concave illuminating mirror below for throwing light upon transparent objects, has a diameter of about 3 inches, and a focal length of about $2\frac{5}{10}$. M. Amici has been able to apply to this instrument a power of *one million**, calculating the number of times that the superficies is magnified, whereas the best microscopes of Adams, Dollond, Delebarre, do not magnify more than 225,000, or about 475 times in diameter. See *The Edinburgh Philosophical Journal*, Vol. i. p. 135, where a more detailed account of this instrument will be found.

IV. *Dr. Brewster's Reflecting Microscope.*

This instrument, which will be understood from Plate CCCLXXVII. Fig. 22, possesses several advantages, and in particular that of being applicable to the stand and apparatus of any compound microscope. Though it is drawn in a horizontal position, it is intended to be placed vertically. It consists of a concave speculum AB, whose surface is a portion of an ellipsoid, having F and *f* for its foci. It is perforated at O, like the speculum of a Gregorian telescope; and between this aperture and F is placed a small convex speculum *s*, whose surface is part of an ellipsoid, having F and ϕ for its foci, $s\,\phi$ being equal to MN, the distance of the object. The back of the speculum is ground into a concave form *a b*, for the purpose of condensing the light upon the object MN. The rays diverging from MN are made to diverge still more by reflection from the small mirror *s*, so that F is their virtual focus; and these reflected rays, falling upon the speculum AB, as if they had diverged from one of its foci F, will be reflected to *f*, and there form a magnified image, which will be again magnified by the eye-glass placed at LL. The convex mirror *s* is carried by the arm *s r*, which is moved by means of the screw *r* T, so that F is one of its foci. An object placed at MN will therefore be seen very distinctly by a microscope of this kind; and it has such a distance from the mirror AB, as to be capable of receiving any degree of artificial illumination. If this microscope is placed vertically in the arm ED of the compound microscope shown in Fig. 19, made large enough to receive it, it may be used along with all the apparatus adapted to that or to any other compound microscope. If a change of magnifying power is required, we have only to use a deeper eye-glass LL; and as the place of the object is not altered by this change, the concave illuminating speculum *a b* will still condense upon the object MN, the light reflected from the great mirror G, Fig. 19.

V. *Mr. Waddel's Compound Microscope.*

A very ingenious and useful compound microscope, represented in Plate CCCLXXVII. Fig. 23. Nos. 1, 2, and 3. has been constructed by Alexander Waddel, Esq. Leith, which possesses many advantages. It is founded on the properties of the astronomical telescope; which, as it inverts the objects, has a right-angled triangular prism A affixed to the outer end of it, at a certain point in the anterior focus of the object-glasses; and by placing the instrument in a vertical, but somewhat inclined position, as in No. 1, and the eye at the dioptric eyepiece E, a picture will be seen within it of the external objects, *erect*, but *reversed*. If this instrument be placed in a horizontal position, as in No. 2, and another right-angled triangular prism affixed to the outside of the eyepiece at E, in a position perpendicular to the other prism, and the instrument so placed that external objects come into it from the observer's left hand side, then, by placing the eye at the last mentioned prism, and adjusting the

* This is 1000 times reckoned in the usual way.

sliding tubes to the sight, a picture of the external objects will be seen distinctly formed within the instrument exactly as it is in nature, neither being inverted nor reversed; and if this last prism have an opening in the lower side of its cover, as in the camera lucida, by a similar adjustment of the eye, the picture within the instrument will appear to be painted on a table under the prism, and may be copied by drawing with a pencil the outline, on a paper placed for that purpose, as is done in the camera lucida.

The way in which Mr. Waddel has commonly made use of this instrument as a *compound microscope* is, by placing it on a stand in a vertical but somewhat inclined position, as at first mentioned, with one of its prisms affixed to the object-end of it; and when the whole of the tubes are drawn fully out, the length of the instrument from the extremity of the prism at one end, to the outside of the eye-piece at the other, is from 9 to 10 inches; which length has been found by the aid of two object-glasses of a compound focus, of about one and a half inch, and a Huygenian eye-piece, with a double eye-glass, of a compound focus of about three-fourths of an inch, to produce a magnifying power, in surface, of about 1020 times, and by applying to the outside of the said object prism an additional magnifier, a much greater power is obtained.

The largest tube of this instrument is less than two inches in diameter; and when the other three sliding tubes are pushed into it, with the prism attached to the object end of it, the whole length very little exceeds 5 inches. From its particular construction, it produces, as an astronomical telescope, a magnifying power of about two and a half times, and the field of view subtends an angle of about 30 degrees. It will be seen from this description of the instrument, that it not only combines the properties of a compound microscope, but of a camera obscura, camera lucida, and diagonal mirror; and that in the first and last of the three foregoing positions, it also becomes an excellent drawing instrument by the aid of a micrometer placed within it near the field-bar of the eye-piece.

An instrument of this construction has been found very useful in botanical and mineralogical pursuits, as objects may be viewed by it under different circumstances with the object-prism, by drawing out or pushing in the sliding tubes, which increases or diminishes the magnifying power at pleasure, without the application of any additional magnifier.

As objects viewed by this instrument are reversed when only one prism is employed, and as certain imperfections arise from the increase of refraction and reflection, when two prisms are used, to render the objects neither inverted nor reversed, it occurred to Mr. Waddel, that some advantages might result from uniting the two prisms in one, as in Fig. 23 No. 3; which he effected by forming two right-angled triangular prisms out of one piece of glass, in such a way that the two reflecting surfaces were at right angles to each other. When a prism of this construction is applied to the object end of the instrument, with one half of it placed in the axis, and the other half without, and the instrument held in a vertical position, so as to admit external objects from the observer's left hand, then, by looking into it with the dioptric eye-piece, a picture will be formed as in nature, neither inverted nor reversed, which may be correctly copied by the aid of the micrometer before mentioned; and when at the other end, becomes a camera lucida. Transparent objects may also be viewed by this instrument in the ordinary way, either with or without the prism affixed to the object end of it.

VI. *Description of a New Compound Microscope for examining objects of Natural History* *

" The construction both of single and compound microscopes has, within the last fifty years, been brought to a great degree of perfection; and, for all the purposes of amusement and general observation, these instruments may be considered as sufficiently perfect. But when we employ the microscope as an instrument of discovery, to examine those phenomena of the natural world which are beyond the reach of unassisted vision, and when we use it in ascertaining the anatomical and physiological structure of plants, insects, and animalculæ, we soon find, that a limit, apparently insuperable, is set to the progress of discovery, and that it is only some of the ruder and more palpable functions of these evanescent animals that we are able to bring under observation. Naturalists, indeed, are less acquainted with the organization of the microscopic world, and the beings by which it is peopled, than astronomers are with those remote systems of the universe which appear in the form of nebulæ and double stars. It was the improvement of the telescope alone which enabled Dr. Herschel to fix the views of astronomers upon those regions of space, to which, at a former period, their imaginations could scarcely extend; and when the microscope shall have received a similar improvement, we may look for discoveries equally interesting, though less stupendous, even in those portions of space which are daily trampled under the foot of man.

" It is both important and interesting to inquire into the cause of this limitation of microscopical discovery. The construction of single lenses for the simplest form of the instrument, has been brought to great perfection. I have in my possession glasses executed by Mr. Shuttleworth, of the focal length of $\frac{1}{50}$, $\frac{1}{40}$, and $\frac{1}{30}$ of an inch, which are ground with great accuracy; and the performance of single lenses has been recently improved by Dr. Wollaston, as described in p. 240. We cannot, therefore, expect any essential improvement in the single microscope, unless from the discovery of some transparent substance, which, like the diamond, combines a high refractive power with a low power of dispersion.

" In the combination of single lenses to form the compound microscope, opticians have likewise arrived at a great degree of perfection. The aberration of refrangibility can now be completely removed by a suitable arrangement of the individual lenses; and every artifice has been exhausted in suiting the apparatus to the various tastes of purchasers, and to every purpose of popular observation.

" No attempt, however, appears to have been made by opticians to fit up the microscope as an instrument of discovery, to second the labours of the naturalist in preparing the subjects of his research, and to *accommodate the instrument to that particular kind of preparation which is indispensably necessary for the preservation and inspection of minute objects.*

* From Dr. Brewster's *Treatise on New Phil. Instruments, p.* 401—410.

"In perusing the writings of those naturalists who have applied the microscope to the examination of minute objects, we find, that the most difficult and perplexing part of their labour consisted in preserving and preparing the different insects and substances which they wished to inspect. Small insects instantly shrivel up and lose their natural form as soon as they are killed, and the minute parts of plants suffer a similar change from exposure to the air. Hence Swammerdam and Lyonet killed the insects which they meant to examine, by suffocating them either in water, spirit of turpentine, or diluted spirits of wine. The softness and transparency of their parts were thus preserved during the process of dissection, and when they were completely developed, the insect was allowed to dry before it was presented to the microscope. Its parts were consequently contracted, and lost not only their proper shape, but that plumpness, and that freshness of colour which they possessed when alive.

"In the preparation, indeed, of almost every object of natural history that is composed of minute and delicate parts, it must be preserved by immersion in a fluid; the dissection must often be performed in the same medium; it must be freed from all adhesive and extraneous substances, by maceration and ablution in water; and when it has undergone these operations, it is in a state of perfection for the microscope. Every subsequent change which it undergoes is highly injurious; it shrivels and collapses by being dried; its natural polish and brilliancy are impaired; the minute parts, such as the hairs and down, adhere to one another, and the general form of the object, as well as the disposition of its individual parts, can no longer be distinctly seen.

"It is therefore a matter of considerable importance to be able to examine the object when wet, and before it has suffered any of these changes; and by fitting up the microscope in the following manner, this may be effected without even exposing the object to the air.

"The object-glass of the compound microscope should have the radius of the immersed surface about nine times the focal distance of the lens, and the side next the eye, about three-fifths of the same distance. This lens should be fixed into its tube with a cement which will resist the action of water or spirits of wine; and the tube, or the part of it which holds the lens, should have an universal motion, so that the axis of the lens may coincide to the utmost exactness with the axis of the tubes which contain the other glasses.

"Several small glass vessels must then be provided, having different depths, from one inch to three inches, and having their bottom composed of a piece of flat glass, for the purpose of admitting freely the reflected light which is intended to illuminate the object. The fluid in which the object has been preserved, or prepared, is next put into the vessel; and the object itself, placed upon a glass stage, or if necessary fixed to it, is immersed in the fluid. The glass vessel is now laid upon the arm of the microscope, which usually holds the object, and the lens is brought into contact with the the fluid in the vessel. The rays which diverge from the object emerge directly from the fluid into the object-glass, and therefore suffer a less refraction than if it had been made from air; but the focal length of the lens is very little increased, on account of the great radius of its anterior surface. The object may now be observed with perfect distinctness, unaffected by any agitation of the fluid;—its parts will be seen in their finest state of preservation;—delicate muscular fibres, and the hairs and down upon insects, will be kept separate by the buoyancy of the fluid; and if the object when alive, or in its most perfect state, had a smooth surface, its natural polish will not only be preserved but heightened by contact with the fluid. Aquatic plants and animals will thus be seen with unusual distinctness, and shells and unpolished minerals will have a brilliancy communicated to their surfaces, which they could never have received from the hands of the lapidary. If the specific gravity of the substance under examination should happen to be less than that of the fluid, and if it cannot easily be fixed to the glass stage, it may be kept from rising to the top by a piece of thin parallel glass, or by a small grating of silver wire stretched across the vessel.

"The method of fitting up and using the compound microscope, which has now been described, enables us, in a very simple manner, to render the object-glass perfectly achromatic, without the assistance of any additional lens. The rays which proceed from the object immersed in the fluid, will form an image of it nearly at the same distance behind the lens, as if the object had been placed in air, and the rays transmitted through a plain concave lens of the fluid combined with the object-glass. If we, therefore, employ a fluid whose dispersive power exceeds that of the object-glass, and accommodate the radius of the anterior surface of that lens to the difference of their dispersive powers, the image will be formed perfectly free from any of the primary colours of the spectrum. The fluids most proper for this purpose are,

Oil of cassia.	Oil of sassafras.
Oil of anise seeds.	Oil of sweet fennel seeds.
Oil of cummin.	Oil of spearmint.
Oil of cloves.	Oil of pimento.

"These oils are arranged in the order of their dispersive powers; and when those at the top of the list are used, the anterior surface of the object-glass will require a greater radius of curvature than when those at the bottom of the list are employed. Thus, in order to render the object-glass achromatic, when it is made of crown glass, and when the fluid is oil of cassia, the radius of the anterior or immersed surface, should be to that of the surface next the eye as 2.5 to 1. Lest these proportions should not exactly correct the chromatic aberration, it would be preferable to make the radii as 2.2 to 1, and then reduce the dispersive power of the oil of cassia by oil of olives, or any other less dispersive oil, till the correction of colour is complete. If the oil of sweet fennel seeds is used, the radius of the anterior should be to that of the posterior surface, as 0.8 to 1."

VII. *On the Magnifying Power of Compound Microscopes.*

When the microscope consists of two lenses, or of one speculum and one lens, the object is magnified from two causes; *first*, from the enlargement of the image produced by the object-lens or speculum, which is always equal to the quotient, arising from dividing the distance of the image from the object-lens or speculum, by the distance of the object from the same; and, *secondly*, from the effect produced by the eye-glass, which is always equal to the quotient arising from dividing the distance at which the eye sees distinctly by the focal length of the eye-glass. The product of these two quotients will therefore be the magnifying power of the microscope. Hence, calling f the focal length of the eye-glass, D the distance of the object from the object-glass, d the distance of the image, and Δ the distance at which the eye sees objects distinctly, we shall have the magnifying power or M, by the following formula,

$$M = \frac{d}{D} \times \frac{\Delta}{f}$$

If a third, or amplifying glass is added, as in the common compound microscope, for the purpose of enlarging the field, the magnifying power of the instrument is diminished, and may be found by multiplying its magnifying power without the amplifying glass, as given by the above formula, by the fraction $\frac{L}{\phi}$; ϕ being the focal length of the amplifying lens and $L = \frac{\delta^2}{\delta - \phi} - \overline{d' - f}$, δ being the distance of the first and second glasses, and d' the distance of the first and third glasses. Hence we obtain the following general rule. Divide the difference between the distance of the two first lenses, or those next the object, and the focal distance of the second or amplifying glass, by the focal distance of the second glass, and the quotient will be a *first number*. Square the distance between the two first lenses, and divide it by the difference between that distance and the focal distance of the second glass. From this quotient subtract the excess of the distance between the first and third glass above the focal length of the third glass, and divide the remainder by the focal distance of the third glass, or that next the eye, and a *second number* will be obtained. Multiply together the first and second numbers, and the magnifying power of the object-glass as found from the rule in p. 243. col. 1, and the product will be the magnifying power of the compound microscope.

The preceding rules for calculating the magnifying powers of microscopes, are founded on the principles which have been adopted by all optical authors; but it will appear, we trust, from a very slight consideration of the subject, that the magnifying power thus found is not the real measure of the assistance afforded by the microscope. Let us take the case of a compound microscope, with two lenses, and let us suppose that the distance of the object from the object-lens is one foot, the distance of the image behind it 20 feet, the focal length of the eye-glass 1 inch, and the distance at which the eye sees microscopic objects 6 inches. Hence the magnifying power of this microscope, computed on the old principle, is $\frac{20}{1} \times \frac{6}{1} = 120$ times; that is, *the object appears* 120 *times larger than if it had been placed at the distance of* 6 *inches from the eye.* But the object is actually placed at the distance of 21 feet from the eye, and the image is not only magnified 20 times by the object-glass, but it is brought to such a distance that the eye can see this magnified image at the distance of 6 inches. Hence the real magnifying effect, by the object-glass alone, is $\frac{20 \text{ feet}}{1} \times \frac{21 \text{ feet}}{\frac{1}{2}} = 840$; and when we look at this image with an inch eye-glass, it is again magnified 6 times, and the total magnifying power is $840 \times 6 = 5040$ times, in place of 120, according to the old principle.

Although this is obviously a correct measure of the benefit which the eye derives from the microscope, and of the effect of the instrument, yet it will be said that, though the object is placed at the distance of 21 feet from the eye, the eye *can* advance to it and examine it at the distance of 6 inches, so that 120 times is the measure of the assistance which the eye receives when it has placed itself in the best position for examining the object. This is undeniable; but we might as well say that a telescope directed to a table of logarithms, at the distance of 1000 feet, did not magnify 20 times (provided that was its magnifying power) because the observer could advance to the book, and see the figures under a larger angle with his naked eye.

If we suppose that the microscopic object is placed in a cavity, whose depth is 12 inches, then, if the observer does advance to it, he cannot see it at a less distance than 12 inches; so that even on the old principle the magnifying power is 240 times. If the object is placed in a position where the eye cannot advance to it at all, then, on every principle, the real power is 5040.

VIII. *On the Method of viewing and illuminating Microscopic Objects.*

The art of illuminating microscopic objects is not of less importance than that of preparing them for observation. No general rules can be given for adjusting the intensity of the illumination to the nature and character of the object which is to be examined; and it is only by a little practice that this art can be acquired. In general, however, it will be found that very transparent objects require a less degree of light than those which are less so; and that objects which reflect white light, or which throw it off from a number of lucid points, require a less degree of illumination than those whose surfaces have a feeble reflective force.

Most opticians have remarked, that microscopic objects are commonly seen better in candle light than in day light, a fact which is particularly apparent, when very high magnifying powers are employed; and we have often found, that very minute objects, which could scarcely be seen at all in day light, appeared with tolerable distinctness in candle light. So far as we know, the cause of this has not been investigated; and as it leads to general views respecting the illumination of microscopic objects, we shall consider it with some attention.

Let LL, Plate CCCLXXVII. Fig. 24, be a single microscope, placed before the eye at E, and let f be a microscopic object, placed in its anterior focus, and illuminated by two candles at A and B. As the rays Afa, and Bfb cross at f, the focus of parallel rays, and as the two shadows of the microscopic object will be formed at a and b, as it were by rays diverging from f, the images of these two shadows formed upon the retina will coincide, and make only one image, so that the object f will appear perfectly distinct. If the object, however, is placed either within or without the focus f, its shadows being formed as it were by rays diverging from a point either within or without, the principal focus f, will not coincide on the retina, but appear to form two images, either overlapping each other, or completely separated. If instead of two candles A, B, we have 4, 5, or 6, we shall have 4, 5, or 6 overlapping or separated images. Now, as it is impossible to place the different parts of a microscopic object exactly in the focus *f*, and as every lens has different foci for the differently coloured rays, and even for homogeneous light, in consequence of its spherical aberration, it necessarily follows, that when microscopic objects are illuminated by light proceeding from several points, the image of it upon the retina must consist of a number of images not accurately coincident; and hence it becomes of the greatest importance that it be illuminated only from one point, and not from a large surface of light, such as the sky, which is equivalent to an infinite number of radiating points.*

The following rules may therefore be laid down respecting the illumination of microscopic objects, and the method of viewing them.

1. The eye should be protected from all extraneous light, and should not receive any of the light which proceeds from the illuminating centre, excepting that portion of it which is transmitted through, or reflected from the object.

2. Delicate microscopical observations should not be made when the fluid which lubricates the cornea of the observer's eye happens to be in a viscid state, which is frequently the case. See Brande's *Journal*, vol. ii. p. 127.

3. The figure of the cornea will be least injured by the lubricating fluid, either by collecting over any part of the cornea, or moving over it, when the observer is lying on his back, or standing vertically. When he is looking downwards, as into the compound vertical microscope, the fluid has a tendency to flow towards the pupil, and injure the distinctness of the vision.

4. If the microscopic object is longitudinal, like a fine hair, or consists of longitudinal stripes, the direction of the lines or stripes should be towards the observer's body, in order that their form may be least injured by the descent of the lubricating fluid over the cornea.

5 The field of view should be contracted so as to exclude every part of the object excepting that which is under immediate examination.

6. The light which is employed for the purpose of illuminating the object should have as small a diameter as possible. In the day time it should be a single hole in the window-shutter of a darkened room, and at night it should be an aperture placed before an Argand lamp.

7. In all cases, and particularly when very high powers are requisite, the natural diameter of the light employed should be diminished, and its intensity increased by optical contrivances.

8. When a strong light can be obtained, and indeed in almost every case, homogeneous light should be thrown upon the object. This may be done, either by decomposing the light with a prism, or by transmitting it through a coloured glass, which has the property of admitting only homogeneous rays.

CHAP. III.

On Solar Microscopes.

The solar microscope is an instrument for representing, upon the wall of a dark room, magnified representations of minute objects, illuminated by the condensed light of the sun. It was invented, in the year 1738, by Dr. Lieberkhun, who, in the winter of 1739, when he was in London, showed one constructed by himself, to several members of the Royal Society, and several opticians, particularly Mr. Cuff and Mr. Adams. Lieberkhun's solar microscope had no mirror for reflecting the sun's rays into the tube; but Mr. Cuff soon saw its imperfections, and constructed one in a very improved form.

Mr. Cuff's solar microscope was composed of a tube, a looking-glass, a convex lens, and a Wilson's microscope. The sun's rays were directed by the looking-glass through the tube upon the object, placed a little before the anterior focus of the convex glass. The image of the object was thrown upon a screen of white paper, and its magnitude was proportional to the distance of the screen from the convex lens.† M Lieberkhun afterwards adapted the solar microscope to the representation of opaque objects; but he did not leave behind him any account of the method which he followed.

M. Æpinus was the first person who described an apparatus for illuminating opaque objects in the solar microscope. If we suppose *e f*, Plate CCCLXXVII. Fig 25. to be the object placed before the convex lens K, he attached to the tube MNOP, two parallel brass plates AB, AC, one of which, AB, moved round a joint at A, and could be placed at any angle with AC by means of the screw C*n* and spring *s*. On the lower end of AB and below K, he fixed a mirror *b d*, which received the rays *a c* from the illuminating glass NP, and threw them upon the front of the object *e f*. By turning the screw C *n*, these rays could be reflected at pleasure upon any part of the object. See *Nov. Comm. Petrop.* vol. ix. p 326.

The solar microscope received great improvements from Mr Benjamin Martin, who has given an account of them, in his *Description and use of an Opaque Solar Microscope*. 8vo. 1774 This instrument is represented in Plate CCCLXXVII Fig. 26—33. with all the parts which are used both for transparent and opaque objects. In Fig. 26. it is shewn as fitted up for opaque objects. In Fig. 27. is represented that part of it, called the single tooth and pinion microscope, which is used for shewing transparent objects. The cylindrical tube Y slides in the tube EF, Fig 26. and in order to use it as a single microscope, a handle *c* screws into a female screw at *g*, and the tube Y is removed. The slider shewn in Fig. 28. and containing six magnifiers, fits

* These observations suggest a new method of finding the principal focal length of a lens LL. Having placed two candles A, B, at a great distance from one another, move a small object backwards and forwards, till it appears to be single. The point *f*, where the two shadows thus coincide, will be the focal point required. The diagram suggests also the construction of a very simple microscopic micrometer, the distance of the body to be measured from *f* affording a measure of its diameter. The length of the scale will increase, as AB, the distance of the lights or luminous aperture, diminishes.

† See *Phil. Trans.* 1749, vol. xli. p. 503. It appears that the apparatus for viewing the circulation of the blood in frogs and mice, was invented by a Dr. Alexander Stuart.

into a dovetail circle P, Fig. 27. The slider at Fig. 29. slides in at *h*, Fig. 27. and is used to condense the sun's rays strongly on the object. Three of them marked 1, 2, 3, are used, corresponding to the numbers in Fig. 28.

The body of the solar microscope is shown at ABCDEF, the part ABCD being conical, and the part CDEF cylindrical. This last part receives the tube G of the opaque object-box. A large concave lens is placed at AB for receiving the rays from the mirror ONP, and converging them into the box HILX.

A brass frame NOP is fixed to the moveable circular plate *a b c*, and carries a plane mirror for reflecting the sun's light upon the convex glass at AB; and by means of rackwork moved by the nuts Q and R, this mirror can be turned into such a position with respect to the incident ray, that the reflected ray passes along the axis of the tubes. The microscope is fastened to a window-shutter by two screws *d*, *e*. The box HILX for opaque objects is shown open. It contains a plane mirror M for reflecting the light from the lens AB upon the object, and this mirror is adjusted through the door *k i* to the proper angle by a screw S. Two tubes of brass are shown at V and K, one sliding within the other, and the outer one V sliding into the box. These tubes carry two magnifying lenses. The interior tube is sometimes taken out, and the exterior one (which is seen within the box) is then used alone.

A brass plate H has its back part fixed to a tube *h* by means of a spiral wire within the tube, which always presses the plate against the side H of the box. The sliders, with the opaque objects shown in Plate CCCLXXVII. Fig. 30. pass between this plate and the side of the box, which is done by drawing out the plate H by means of the nut *g*. The following are the other parts of the opaque solar microscope.

Fig. 32. is a brass quadrangular slider case, to hold any animal or opaque object, which is to be placed at H, like the other sliders.

Fig. 33. is a four glass slider in a brass frame, for animalculæ &c. which is to be placed between the plates at *m*, Fig 27.

Before using the solar microscope, a circle a little larger than *a b c*, must be made in the shutter of a window opposite to the sun. The mirror NOP is then put through this hole, and the square plate applied to the shutter. The places corresponding to the two holes of the screws *d*. *e*, are then marked on the shutter with a pencil, and holes made large enough to admit the screws, which, passing through the shutter, are screwed into their respective holes in the square plate, so as to hold the microscope firmly in its position.

In order to use the microscope for opaque objects, the mirror NOP is turned by the screws Q, R, one of which gives it a circular motion, and the other raises or depresses it, till it reflects the sun's rays through the tube ABEF upon a white paper screen or cloth, from 4 to 8 feet square, placed at a distance of from 5 to 8 feet from the window The tube G of the box HILX is then put into the tube EF, and the mirror M is adjusted through the door *k i* till the objects are strongly illuminated. The door *k i* being shut, a distinct image of the object will be obtained upon the screen, by adjusting the tubes V and K with the magnifiers, which is done by moving them backwards and forwards As the sun is always in motion, it is necessary to shift the place of the mirror NOP, so as to keep the reflected light coincident with the axis of the tube. This effect may be produced in a superior manner by adapting the solar microscope to a Heliostate (see that article) or piece of clock-work, which drives the mirror continually, so as to make it always reflect the sun's light in one direction.

In order to use the microscope for transparent objects, take away the opaque box HILX, and insert the tube Y of Fig. 27. in EF. Place the slider, Fig. 28. in its place at *n*, a condenser, Fig. 29. into the opening at *h*, and the slider, Fig. 32. with the objects between the plates at *m*: then, having adjusted the mirror NOP as before, a magnificent picture of the object will be seen on the white screen.

The solar microscope now described, though possessing all the advantages that can arise from mechanical construction, is still a very imperfect instrument, being liable to all the bad effects arising from the different refrangibility of light.

The only method of remedying this defect, is to correct the colour, either by using a combination of lenses for the purpose of forming the image, or to use a lens composed of differently dispersing and refracting media.

We have already shown in the article Achromatic Telescope, that achromatic eye-pieces may be constructed with two, three, or four lenses, and therefore we have only to substitute one of these eye-pieces in place of the lenses of V and K, Fig. 27. Dr. Robison tried the eye-piece of Ramsden, described in the above article, (where, by the way, one of the focal lengths is stated at 7.025 in place of 1.025) as the magnifier of a solar microscope, and found it to surpass every thing that he had seen. "The picture formed by a solar microscope," says he, "is generally so indistinct, that it is fit only for amusing ladies, but with this magnifier it seemed perfectly sharp. We therefore recommend this to the artists as a valuable article of their trade."

Another mode of improving the solar microscope has been described by Dr. Brewster, in his *Treatise on New Philosophical Instruments*, and is founded on the principle already explained, (see p. 248.) as applicable to the compound microscopes.

The method of fitting up the solar microscope, to render it susceptible of this improvement, is represented in Plate CCCLXXVII. Fig. 34. where AB is the illuminating lens which receives the parallel rays of the sun, and throws them upon the object. The object lens CD is firmly cemented into one end of a tube *m* CD *n*, which has a tubular opening at E; and at the other end of the tube is cemented a circular piece of parallel glass *m n*. The tube *m* CD *n* is then filled with water, or any other fluid; and the object, when fixed upon a slider, or held with a pair of forceps, is introduced into the fluid at the opening E. The slider, or the forceps, may be easily rendered moveable, so that the object may be placed at a proper distance from B; or the adjustment may be effected by a motion of the screen on which the image is projected. The plate of glass *m n* might be removed, and the whole of the space between AB and CD filled with fluid; but if the fluid had any tinge of colour, the transmitted light would, in this case, partake of it, and injure the distinctness of the image.

If the microscope is fitted up for the examination of transparent bodies, it is obvious, that the image will be much more perfect than if it had been formed in the common way. The opacity which arises from a contraction of parts is thus completely removed, and an additional transparency is communicated by the fluid, which could not have been obtained in any other way. Substances, indeed, which with the common solar microscope appear opaque, will, in the present form of the instrument, exhibit a very great degree of transparency. The advantages arising from immersion in a fluid, which have been very fully stated in Chapter II. p. 248, apply with peculiar force when the objects are used in the solar microscope.

This microscope may be rendered perfectly achromatic, by using the same fluids, and by giving the lens nearly the same radii of curvature, which have been already mentioned.

CHAP. IV.

On the Lucernal Microscope.

The lucernal microscope is an instrument for exhibiting to one or more persons magnified representations of microscopic objects when illuminated by an Argand lamp. It was invented by Mr. Adams, and has the property of enabling the observer, who has no knowledge of drawing, to make an exact delineation of the object he is examining.

It is represented in Plate CCCLXXVII. Fig. 35, 36, 37, and 38. In Fig. 35. it is fitted up for viewing opaque objects, and consists of a large pyramidal box of mahogany ABCDE, about 14 inches long, and six inches square at its large end. This box is supported on a brass pillar FG, by means of the socket H, and the curved piece IK. At N is a dove-tailed piece of brass for receiving the dove-tail at the end of the piece LMN. The part MN consists of two brass tubes, one sliding within the other, and the inner one carries the flat piece of brass LM, at the top of which is a hole L for the eye. This piece may be raised or depressed, and fixed in any position by a milled screw at M, and it may be made to approach to or recede from the box, by pulling out or pushing in the tube M to which it is attached. At the other end of the box is fixed a tube P, which receives another tube O, at the end of which the magnifiers are fixed. A long square bar RS, which passes through the sockets YZ, carries the stage *f g h i* that holds the objects. This bar may be moved backwards or forwards, for the purpose of adjusting the stage, by means of a pinion at *a* working in a rack; and this pinion is moved either by a handle *b c* furnished with an universal joint, or by the screw-nut shown separately in Fig. 36. The body of the microscope is kept steady by the brass bar *d e*, which sustains the curved piece KI.

The objects are placed in the front side of the stage *f g h i*, between four small brass plates, the edges of two of which are seen at *k* and *l*. The two upper pieces of brass, which are moveable, are fixed to a plate which is acted on by a spiral spring, that presses them down and confines the slider. This plate, and the two upper pieces of brass, are lifted up by the small nut *m*.

The Argand lamp, shown in Fig. 37. throws its light upon a glass hemisphere *n*, which conveys it to the concave mirror *o*, from which it is reflected upon the objects.

When the stage for transparent objects, shown in Fig. 38. is to be used, the upper part *f g r s*, of the opaque stage is taken out, and the two legs 5 and 6 of the transparent stage fit into the under part *r s*. The sliders are confined at 7, and the lenses for condensing the light are placed in the brass tubes 9, 10, which may be drawn out or pushed in by the pin 11. The magnifiers are screwed into the hole 12, and are adjusted by the nut 13, working in a rack 1, 2.

At the end AB of the wooden body, there is a slider represented as partly drawn out at A. When it is taken completely out, three grooves will be seen, one of which contains a board forming the end of the box, the next a frame with a ground glass, and the third, (or that farthest from AB,) two large convex lenses.

When the instrument is fitted up as shown in the figure, it is ready for adjustment. The lamp being placed before the glass hemisphere *n*, the mirror *o* must be inclined till it receives the light from the hemisphere, and reflects it upon the objects. The wooden slide A being taken out, and the cover and the ground glass removed from their respective grooves, the piece LM is pulled out or pushed in, and raised or depressed till the eye at L sees the large lens placed at the end AB of the wooden body, filled by an uniform field of light. The eye still looking through the aperture at L, the lenses are adjusted to their focal distance by turning the pinion A, and the ground glass is placed before the large lenses. The image of the objects will now be seen beautifully depicted upon the ground glass, and may be accurately delineated upon it with the point of a pencil. The objects, when magnified, are seen to the greatest advantage by a single observer, when his eye is applied to the aperture L, but if two or three persons wish to see the objects at the same time, the guide LM must be removed. The large lens must be taken out of the groove, and the image received on the rough glass.

Some slight improvements have been made on the Lucernal microscope by opticians, and by the Rev. Dr. Prince and Mr. Hill, an account of which will be found in Adam's *Essays on the Microscope*, 2d Ed. p. 84, &c.

Account of a New Method of illuminating Objects in the Solar and the Lucernal Microscopes.

The great effects which still attach to the solar and lucernal microscopes, arise from the imperfect method of illuminatiag the objects. The method suggested by Æpinus, and employed almost universally by opticians, of reflecting the light concentrated hy a lens upon the objects by means of a plane-mirror, is good enough so far as it goes; but in consequence of the light arriving from one direction only, the surface of the illuminated object is covered with deep shadows; and the intensity of illumination is by no means sufficient when the power of the instrument is considerable.

We propose, therefore, that in the solar microscope the sun's light should be reflected by a very large mirror through four apertures, A, B, C, D, each of which is furnished with an illuminating lens, such as NP, Fig. 25. or *n*, Fig. 35. The four cones, if condensed, are then received before they reach their focus, by an inclined mirror, such as *ab*, Fig. 25. or *o*, Fig. 35. which reflects them upon the object *ef*; the distance $ab+bf$ being always less than the focal length of the illuminating lens NP. In the lucernal microscope, it would be adviseable to place an Argand lamp opposite each of the apertures A, B, C, D. By these means the light would fall upon the surface of the object in four different directions; a high degree of illumination would be obtained for very dark objects, or for high powers; and by shutting up one or more of the four lenses, or parts of them, we should be enabled to find the particular direction of the light which is best suited for developing the structure, which it is the object of the observer to discover.

CHAP. V.

On Microscopic Objects.

Almost every object in nature may be considered as an object fit for the microscope, either as a whole, if it is small, or in its parts, if it has considerable magnitude. The name of microscopic objects, however, is generally given to those minute animals which cannot be seen without the microscope, or to particular structures in the animal, vegetable, and mineral kingdom, which are remarkable for their beauty when examined by the microscope.

In our article ANIMALCULE, we have already entered into great detail respecting the most interesting animals which have been discovered by the microscope, and have represented some of the most important in Plates XXIII. and XXIV. We shall therefore confine ourselves at present to a brief enumeration of microscopic objects which possess a particular interest.

List of the most interesting Microscopic Objects.

I. *Animalcules.*

Hydræ, or polypi, found in stagnant water.
Animalcules found in infusions of hemp seed.
Do. in milk, blood, urine, and other animal fluids.
Do. in fetid sea-water.
Do. in infusions of grass and hay.
Do. in dunghill water.
Do. in infusions of pepper, coriander seeds, and cassia, and in the juice of the beet root, &c.
Do. in an infusion of the *sonchus arvensis.*
Do. in water where duckweed grows.
Do. in yellow ochry slime that covers pools of standing water.
Eels found in paste.
Do. in vinegar.
Do. in salt water.
Do. in blighted wheat.

The animalcules are generally found in the film or pellicle which covers the surface of infused liquors. It is sometimes necessary to dilute the infusions, which should always be done with distilled water, and the water should be previously examined in the microscope. The animalcules are commonly seen best when the water is a little evaporated.

II. *Insects.*

The common spider, the flea, the bug, mites of a cheese, the gnat, the common louse, the crab-louse, the pigeon-louse, the cattle-louse, the sheep-louse or tick. The death-watch of Linnæus. The podura viridis and aquatica, found on the leaves of plants. The rose-chaffer, the flee beetle. the water-flee, the lady-cow or lady-bird, various species of the genera *Coccinella, Chrysomela, Curculio, Gryllus, Cicada, Cimex, Aphis,* and *Chermes.* The water-scorpion, the mole-cricket, the glow-worm, the earwig.

The LEPIDOPTEROUS insects of the genera *Papilio, Sphinx,* and *Phalæna,* are interesting, from their wings, scales, feathers, proboscis, head, eyes, antennæ, chrysalides, eggs, legs, &c.

The NEUROPTEROUS insects of the genera *Libellula, Ephemera, Phryganea,* &c. from their head, wings, eyes, and antennæ.

III. *Parts of Animals.*

Wings, and legs, and eyes, of flies and other animals.
Scales of fishes. Antennæ of moths and butterflies.
The hair and bristles of animals.
Globules and circulation of the blood.
Feathers } Pith of the feathers cut transversely.
Skins }

IV. *Parts of Plants.*

Section of the trunk and roots. The rhind.
The seeds of plants. The blea.
The stamina.
The pistil. The leaves and their fibres.
The receptacle. The pericarpium.

V. *Sections of Plants.*

The following is a list of the vegetable sections which were made by Mr. Custance, by means of a machine which has been described in the *Phil. Mag.* vol. iii. p. 302. by Dr. Thornton.

English oak. Evergreen, do.
Norway oak. Ash.
Cedar. Cork.
Savin. Fir.
Ceanothus. Hazel.
Lime. Elm.
Elm root. Mulberry, do.
Grape-root. Lime, do.
Beech. Birch.
Plum. Ivy.
Spanish elder. American climber.
Cissampelos. Virgin's bower.
Magnolia grandiflora. Golden rose.
Althæa frutex. Tulip tree.
Spanish chesnut.
Platanus orientalis. Viburnum lantana.
Oak-root. Ash-root.
Asp-root. Walnut, do.
Grape vine. Indian turpeth.
China root. Jasmine.
Dog-rose. Raspberry.
Barberry. Briar.
Elder-root. Ditto, branch.
Willow-root. Ditto, branch.
Mulberry.
Sycamore. Maple.
American dogwood. Ptelea trifoliata.
Ligneous night-shade. Sumach.
Apricot. Medlar.
Bay. Laurel.
Sea-weed. Longitudinal cutting of plane tree.
Ditto of Spanish elder. Ditto of briar.

Common cane. Ditto with curious centre.
Bamboo cane. Sarsaparilla.
Longitudinal cuttings of sugar-cane. Elder.
Rose-tree.
Longitudinal slices of elder.
Ditto grape vine. Transverse, ditto.
Dogwood. Plane tree.
Beech. Grape vine.
Spanish chesnut. Walnut.
Fig. Ditto Longitudinal.
Asparagus. Artichoke.
Thistle. Fennel.
Parsley. Ditto root.
Sun-flower. Ditto root.
Agrimony. Eryngo.
Potato-stalk. Centaurea
Indian reed. Indian corn.
Amaranthus. Bromelia pinguin.
Campanula. Monk's hood.
Lavatera. Solidago.
Mugwort. Chrysanthemum.
Helianthus. Wormwood.
Bulrush. Portugal reed.
Burdoch.
Field-mustard. Aloe-flower stalk.
Solomon's seal. Tulip.
Calamus aromaticus. Buckbean.
Gourd. Melon.
Crown imperial. Flower de luce.
Pine apple. White lily.
Asparagus. Ragwort.
Water-flag. Sugar cane.
Stems of leaves of hog's fennel. Hemlock.
Chesnut. Wild turnip.
Stems of the leaves of Red dock. Horse-radish.
Cabbage. Carrots.
Roots of phytolacca. Teasel.
Carrot. Fennel.
Stinging-nettle roots curiously variegated.
Roots of parsley and wormwood variegated.
Stalks of fern with variations.
Charcoal.—See *Phil. Mag.* vol. iii. Plate VIII. Fig. 5.

VI. *Worms, &c.*

The Gordius aquaticus and lacustris. The common leach, the horse-leach, and the sea-leach. The ascaris vermicularis and lumbricoides. The earth-worm, the sea-worm, the gravel worm. Black, red, and grey snails. The sea lemon. The sea mouse. The nereis noctiluca. The sea-nettle and sea limp. The asterias. Corals, madrepores, millepores, cellepores. Zoophytes, such as sponges, &c.

VII. *Saline Solutions.*

All the alkaline, earthy, and metallic salts, form very interesting microscopic objects when dissolved in water, and allowed to crystallize on a plate of glass by evaporation.

In order to see in perfection, however, the mode in which these bodies crystallize, it is necessary to illuminate them with polarized light, which is best done by substituting in place of the mirror four or five plates of glass laid above each other, so as to reflect the light up the tube at an angle of about 56°, and to apply to the eye-glass a thin plate of agate or tourmaline for the purpose of analysing the transmitted light. The crystallizations will then appear of the most beautiful colours, the tints always varying with the thickness of the crystals.

Description of Microscopic Objects represented in Plate CCCLXXX. and copied from those given by Mr. Adams.

Fig. 1. Is the lobster insect, which is found on the legs of a fly, and also occurs in books and paper, and in plants.
Fig. 2. Is an insect denominated the *Thrips Physapus*, which is found on the Dandelion and other plants and flowers. The body is black, and the wings white.
Fig. 3. Represents the *Cimex Striatus*, a beautiful insect, with its colours very bright, and elegantly arranged. It is found in June on the elm tree.
Fig. 4. Represents the *Chrysomela Asparagi*, which is found in June on the asparagus, after it has run to seed.
Fig. 5. Is the *Meloe Monoceros*, found on umbelliferous plants.
Fig. 6. Represents a scale from the sole fish.
Fig. 7. Is a section of a weed called the fat hen, which grows among rubbish.
Fig. 8. Is the section of a reed from Portugal.
Fig. 9. Is a section of the bamboo.
Fig. 10 Is a section of the hazel.
Fig. 11. } Shew the eggs of moths and butterflies, par-
Fig. 12 } ticularly the *Phalæna Neustria.*

For farther information on microscopes, the reader is referred to the following works:

Fontana, *Novæ Terrestrium et Celestium Observationes*, Neap. 1646 Borelli *De vero Telescopii inventore*, Hag. 1655. Borelli *Centuria Observat. Microscop* Hag. 1656. Hooke's *Micrographia*, Lond. 1665. Hartsoeker's *Essay de Diopt.* Par. 1694. Huyghens *Mem. Acad.* Par. 1666. Tom. X. p 427. Huyghens *Collect. Acad.* Tom. I. p. 281. Hugenii *Opera*, Tom. II. p. 764. Leuenhoek's *Arcana Naturæ*, 2 vols. L. Bat. 1696 Id. *Phil. Trans.* 1673. VIII 6037, 1740. p. 503. Gray. *Phil. Trans.* 1696 280, 353 539. Wilson, *Ph. Trans.* 1782 1241. Butterfield, *Ph. Trans.* 1678. Divini, *Ph. Trans* 1668, p. 842. Bonnani *Observationes Circa viventia quæ in rebus non viventibus reperiuntur, &c.* 1691 Baker's *Microscope made Easy*, 1744. Baker's *Employment for the Microscope.* 1753 Baker's *Catopt. Mic. Philosophical Transactions*, 1736, p. 442. Lieberkhun, *Mem. Acad. Berl.* 1745, p. 18 and *Collect. Academ.* Tom. et p. 39. Benj. Martin's *Micrographia Nova*; Reading, 1742. Martin's *Optical Essays.* Euler. *Nov. Com. Petrop.* III. and XII. 195. 224, p 363. Euler, *Mem. Acad.* Berl. 1757. p. 283, 323, 1761, p. 191, 281. 1769. p. 105 and 117. Æpinus *Nov. Comm. Petrop.* IX. 316. Æpinus *Nov. Act. Petrop.* II. 1784. Hist. p. 41. Zeiher, *Nov. Comm. Petrop* X. p. 299. Di Torre, *Phil. Trans.* 1765, p. 246. Smith's *Optics*, 2 vols. Camb. 1738. Hill's *Construction of Timber explained by the Microscope*, Lond. 1770. Delebarre's *Memoire sur le Microscope.* Gleichen *vom Sonnen Microscope* Nuremb. 1781. Custance's *Machine for making Vegetable Sections. in Phil. Mag.* vol. III. p. 302. Adams *on the Microscope*, 4to. Lond. 1798. Ferguson's

Lectures, vol. II. p. 462. 483. *Edinburgh Phil. Journ.* vol. I. p. 81; vol. II. p. 135; and vol. III. No. I. Wollaston, *Phil. Trans.* 1812, p. 375. Brewster's *Treatise on New Philosophical Instruments*, Edin. 1813, p. 401, 410, 413, 416. (β)

MIDDLEBURG. See WALCHEREN.

MIDDLEMOST KEYS in *music*. The key-notes, thus denominated by Dr. Robert Smith, (p. 164, 2d edit. of his *Harmonics*,) are D and A; which keys have, on the common or 12-note instruments, only one false consonance in each, both of them discords, viz. the 5th of D, (for want of A♭), and the 4th of A (for want of D♯): if one key be added on each side, downwards and upwards, in the order of modulation (by Vths,) these four middlemost keys, viz. G, D, A, and E, (which are the open strings of the violin,) have all their concords true, or according to the system of temperament adopted in the tuning of the instrument; but in G, the 2nd and the 5th are false, and in E, the IVth and the VIIth are false, for want of notes for A♭, D♭, A♯, and D♯. In modulating, either upwards through the keys B F♯, C♯, &c. or downwards through the keys C, F, B♭, &c. the number of false consonances are in either case 3, 4, 5, &c. respectively, increasing in arithmetical progression. It appears from the investigations of Professor Fisher, which have been referred to in our article MEAN TONE SYSTEM, that the frequency of the use of the middlemost keys, D and A, in organ music, is in each case more than double of the use of the key of C, as to frequency.

MIDDLESEX, an inland county in the south-east of England, is bounded on the south by Surry, and a small part of Kent; on the north by Hertfordshire; on the east by Essex; and on the west by Buckinghamshire. Its boundaries on all sides, except the north, are natural; the Thames dividing it from Surry, the Lea from Essex; and the Coln from Buckinghamshire. Its form approaches somewhat to that of a quadrangular; but on its southern side, it is rendered very irregular by the windings of the Thames; and on the northern, a portion of it projects into Hertfordshire. It is inferior in size to all the English counties except Rutlandshire and Huntingdonshire; the medium length is about 20 miles, and the medium breadth 14 miles: its greatest length, from east to west, is 22 miles; and its greatest breadth, 17 miles. Its area is variously computed: Mr. Middleton says it contains 280 square miles, or 179,200 acres. According to the returns to Parliament of the poor rates, drawn up under the inspection of Mr. Rose, it contains 190,080 acres; while other statements extend its area to 217,600 acres. It is divided into 6 Hundreds, viz. Edmonton, Ossalston, Elthorne, Gore, Isleworth, Spelthorne; and into 2 Liberties, viz. Finsbury and Wenloxbarn: the hundred of Ossalston is subdivided into 5 parts; in this hundred London is situated. Besides the metropolis of the British empire, and its contiguous villages, the county of Middlesex contains, as towns of size or consequence, Brentford, Uxbridge, Enfield, Hounslow, &c. being places of very inferior size and population. Besides the parishes which constitute London in its most extended sense, there are in Middlesex 62. This county returns 8 members to parliament; viz. 4 for the city of London, 2 for the city of Westminster, and 2 for the county. It is in the province of Canterbury, and in the diocese of London and Westminster.

Near the banks of the Thames, Middlesex is extremely flat; but as we approach its northern confines, its surface becomes more varied, though in no part can it be called high. The principal hills are at Highwood, Howden, Barnet, Harrow, Highgate, and Hampstead; the last, which is said to be the highest ground in the county, is not more than 400 feet above the Thames. The most picturesque part of the county lies to the north-west of Hamstead, and in the vicinity of Howden; the surface here is undulating, and as there is a sufficiency of wood, and the fields are rich and verdant, the appearance is beautiful as well as picturesque. The soil of Middlesex is not naturally very fertile; the low parts of the county are either of a gravelly or sandy nature; and their fertility is almost entirely owing to manure; gravel and sand are likewise found on some of the highest hills. The best soil lies on the sides of the larger hills, and on the banks of the rivers; these soils are either a strong loam, or a deep, rich, friable loam. In some parts, as near Pinner and Edgware, the soil is a loamy clay. The subsoil, through the whole county, is a gravel strongly tinged with oxid of iron. Indeed the only difference over the whole of lower Middlesex, arises from the greater or less depth of this gravel. Wherever the soil is strong, the gravel lies at a considerable depth; and this is also the case on the alluvial lands, near the Thames and other rivers; but wherever the upper soil is light, there the gravel is comparatively near the surface. All the hollows, bowls, and chinks, are filled with gravel; and the summits of most of the highest hills consist of sand and gravel. This subsoil is also found below the heathy land, between Rickmansworth and Staines. The Isle of Dogs, the flat land on the borders of the Lea and the Coln, and some of the land on the Brent, is marsh soil. The climate of Middlesex is mild, especially on its southern side, near the Thames. Even at the short distance, however, of Highgate and Hampstead, partly owing to the greater elevation, and partly to the soil being stronger and more retentive, the air is considerably sharper. The prevalent winds are from the west and south west, and from the east and north-east; the last prevail in the spring months often for several weeks, and accompanied with a considerable degree of cold. The quantity of rain that falls is less than in most other counties of England, the average not exceeding 24 inches. July is generally a wet month; perhaps the wettest in the year; if not wet, it is often the hottest. The cold in winter is seldom very great; nor does much snow fall, or continue long on the ground. The principal rivers are the Thames, the Lea, the Coln, and the Brent. The Thames first touches the borders of the county near Staines, where it is joined by one of the branches of the Coln; near Brentford, where it inclines to the north, it is joined by the Brent, and, as it leaves the county, it is joined by the Lea. This last river is navigable from the Thames to near Tottenham, about eight miles, where a canal is cut which runs parallel to the river, forming a water-course along the whole eastern border of Middlesex. The New River, as it is called, rises in Hertfordshire, 19 miles from London, though, by its serpentine course, its length is nearly 36 miles. It has 43 sluices, and over it are 215 bridges. Middlesex is intersected by two canals for the purposes of navigation, the Grand Junction and Paddington; the former joins the Thames at Brentford, running by Hanwell, Uxbridge, Harefield, &c.; it admits barges of 70 tons; the rise of water, from its union with the Thames to the 14th lock, is 114 feet 2 inches. The Paddington canal branches off from the former near Cranford; it is intended to carry it from the Paddington to the Thames, near the London docks. There are no minerals in Middlesex, though some curious geological specimens have been found in different parts, especially in Highgate Hill, when the archway was formed.

The vicinity of the metropolis has broken down any large estates that might have formerly existed in this county, as well as given a particular direction to the mode of farming, and the general employment of the ground. Farms in general are small; and the greater part of the county is in meadow, pasture, or garden and nursery-grounds. Corn is an article that can easily be conveyed from any distance, whereas hay, and particularly milk, must be procured for a large town from its immediate vicinity. From the operation of these causes, as well as from the soil in the greater part of Middlesex being better adapted for pasture than corn, it cannot be regarded as an arable county; the land in tillage being calculated only at about one-fifth of the whole, and what is under the plough is not well managed: indeed it cannot be otherwise in a district where the common-field system is so extensive—the common fields containing even yet nearly 20,000 acres; and the commons being much more numerous and extensive than might have been supposed so near the metropolis. The smallness of the enclosures too, (when the arable land is enclosed,) and the great number of trees in the hedge-rows, are much against good and profitable tillage husbandry: but perhaps the chief cause of the inferiority of Middlesex in this respect, must be sought after in the greater profit derived from dairy land, and garden and nursery grounds.

So long ago as the reign of Elizabeth, the soil in the north of the county, especially between Heston and Harrow, was famous for the fine quality of its wheat; but at present the wheat of Middlesex is by no means equal to that of Essex, Herts, or Kent; and, according to Mr. Middleton, there are not above 7000 acres cultivated with this grain. It is sown after beans, pease, tares, clover, or potatoes, in October, November, or December, and is reaped early in August, with a large toothless hook, in the manner called *bagging*, by which means the straw, which brings a very high price in London, is cut very close to the ground. The average produce of the county does not reach three quarters the acre. Rye is seldom cultivated, except for the purpose of being cut as green food in the spring. There is not much barley grown in Middlesex; indeed the soil in many parts is too strong for this species of corn; the number of acres is calculated at about 4000; it is usually sown after wheat or turnips; in the former case, as might be expected, the produce and quality are indifferent; in the latter case, on the sandy loams, they are both good. There are also few oats grown, though on the strong loams their cultivation might be introduced with advantage and profit. The Tartarian oat is usually sown; both oats and barley are mown, except where they are very short, when they are cut with a sickle. Beans are grown on the strong soils in the north and north-west of the county, to the extent perhaps of 3000 acres; in many parts they are dibbled; in others sown broadcast; in the former case, they are kept very clear by hand-hoeing, and the produce is good, as well as the land left in excellent condition; in the latter case, the produce is light, and the land left foul. They are seldom ripe till the beginning of September, when they are bagged like the wheat. Pease are grown extensively, especially on the rich light loams, in the low part of the county; white pease are sown for podding, while green, for Covent Garden market. They are always drilled, and being kept clean, are a very profitable crop. These pease are often sold by the acre, and in all cases, about 40 women and children are employed to pod 10 acres, who are paid either by the day or by the acre, or the quantity gathered: they are gathered into a sack of four heaped bushels. They are delivered to the salesmen in the market from three to five in the morning. The ground is usually picked twice over. The grey pease are suffered to stand till ripe, when they are cut with hooks and rolled into wads. Nearly all the kinds of grain are thrashed with the flail, there being very few thrashing-mills in the county. There are not many potatoes grown in Middlesex; in the north of the county the soil is too strong, and in other parts the crops raised for Covent Garden market are more profitable than potatoes would be. Besides, from the quantity of manure put on the ground, and the slovenly and imperfect manner in which they are cultivated, the quality of the potatoes grown near London is very indifferent. The culture of tares is extending fast, principally as green food, and as a preparation, on stony land, for a crop of wheat. Much of the soil of the county is not fitted for turnips, and even where it is, they are not cultivated so extensively, nor in such perfection as they ought to be. Many are grown for Covent Garden market, and not a few are sold to the cow-keepers. In 1817, owing to the scarcity of turnips, there were instances of cow-keepers giving fifteen guineas an acre for turnips, at the distance of sixteen miles, and being at the expence of pulling them and sending for them. Nothing strikes a stranger more than the immense waggon loads of turnips drawn by six stout horses going to Covent Garden market.

The meadow and pasture husbandry of Middlesex, though better than its arable, is yet very imperfect. Some of the meadows are very rich, especially those on the banks of the Lea; cattle are put upon them from August to April, after which they are shut up for hay. The fertility of these meadows arises partly from the natural fertility of the soil, and partly from their being flooded in winter, and artificially watered in summer. There are also excellent meadows on the banks of the Thames, especially between Chelsea and Fulham, and on the banks of the Coln, from Staines to Harefield. The whole extent of all these meadows is about 2500 acres. The richest grass, however, in the county is in the marsh land of the Isle of Dogs: in it there are about 1000 acres, which lie so low that they would be overflowed by every tide, were it not for embankments. The ground is divided by ditches, by means of which the water is carried off at low tide into the Thames, and thus the pasture is kept dry. It is calculated that there are nearly 18,000 acres of upland meadows and pastures in Middlesex, great part of which bears the marks of having been formerly arable. The soil varies from a poor loam, lying near the gravel, to a rich loam of considerable depth. Great quantities of manure are annually put on these grounds, especially in the immediate vicinity of London, and yet the produce, in respect to quantity, is very inconsiderable; they are pastured till November, or later, if the weather is open and dry, and afterwards shut up for hay. All the meadow land near Islington, Paddington, &c. is in the occupation of the cow-keepers, who mow it frequently two or three times a-year, as their object is to have hay of very fine quality. There is very little land entirely used as pasture. Middlesex has long been famous for its mode of making hay, and certainly the hay is got in with more of its sap in it, and with less labour, than in any other part of England. It is all mown by the acre; each man mowing from $1\frac{1}{2}$ to 2 acres a-day: five hay-makers, men and women, are provided for each mower; every part of the operation is carried on with forks, except clearing the ground, which is done with rakes. The whole time employed seldom exceeds four days: the first day it is spread, turned twice, and raked into rows, and put into small cocks; the second day it is again spread, and shaken into plats of five or six yards diameter, which are turned, and then formed into larger cocks than the first day. On the third day, the hay is put into a state to be carried, and sometimes, indeed, is carried on this day; on the fourth day, unless the weather is very unfavourable, it is always carried. The hay stacks in Middlesex are very neatly made, and well secured. In some parts it is put into barns capable of holding from 50 to 100 loads. No cattle are fattened in this county, but a very large number for supplying London with milk. The cow-keepers in general live at Islington, Hackney, Paddington, &c. They breed very few cattle, generally buying them when three or four years old, and in calf. They are the short horned Poldernesse breed. They are confined in stalls during the night; about three in the morning, grains are given them; from four to half past six they are milked by the milk-dealers, who contract with the cow-keepers for the milking of a certain number of cows; they are afterwards fed with turnips and hay; at eight o'clock put into the cow-yard; at twelve confined to their stalls, and grains given them; and at half-past one they are again milked. In the county of Middlesex there are upwards of 7500 cows kept for supplying London with milk. The quantity given by each cow, on an average, is supposed to be nine quarts a-day, or 3285 yearly. The cow-keeper finds the men who attend to the cows; the cow-dealer the persons who milk them. Every cow-house is provided with a milk room, where the milk is measured, and openly mixed with water from a pump.

The market-gardens in Middlesex are of great extent. They are of three kinds; the fruit, kitchen, and nursery gardens. The first are principally situated between Kensington and the western extremity of the county, and chiefly in the parishes of Chelsea, Fulham, Brentford, Isleworth, and Twickenham. The fruit gardens have two crops growing at the same time on the same ground viz. apples, pears, cherries, &c. which form an upper crop; and raspberries, currants, herbs, &c. which form an under crop. The management of these gardens is, in general, excellent; a wonderful degree of labour and skill are bestowed upon them; and their produce is proportionally lucrative, being calculated to average upwards of £100 per acre. There are upwards of 3000 acres under this cultivation, and they are supposed, during winter, to require five persons per acre, and in summer 10 persons. In summer, a great many Welsh women come up to labour in them. By far the richest kitchen-garden ground in Middlesex, and perhaps in the whole kingdom, is situated in the parish of Chelsea, and the adjoining part of Westminster near the Thames, called the neat-houses. The soil is a rich black loam, evidently formed by deposits from the river, which is here indeed kept off the ground by embankment. In dry weather, these gardens can be watered from the Thames by means of sluices; and their fertility is further secured and increased by at least 60 cart loads of dung laid on each acre annually. All kinds of vegetables are grown here, but chiefly those which, early in the season, bear a high price. The total annual produce is calculated at £250 an acre. The farming gardeners, as they are called, from working their land with the plough, are situated at a much greater distance from London; the crops they cultivate are principally pease for foddering, and turnips, cabbages, carrots, &c. for Covent Garden market. The most extensive and celebrated nursery grounds are either in the west of London, at Chelsea, Brentford, Kensington, Fulham, and Hammersmith, or to the north-east at Hackney and Dalston; there are also some at Bow and Mile-end, &c. No sight more rich and beautiful can be well conceived, than the collection of rare flowers which are to be seen in many of these gardens, and the hot-houses attached to them; and every improvement that ingenuity and science can produce, and capital execute, is to be met with, to bring the plants to the highest state of perfection. Every kind and variety of fruit tree, also, that can be cultivated in this country, is to be found in these nursery grounds. The hedge-row timber in this county, has also been mentioned as abundant; but the natural woods are very trifling, and are constantly decreasing, and scarcely any timber is planted. On the banks of the Thames, and the small islands in that river, between Staines and Fulham, a very considerable profit is made by the cultivation of osiers for the basket-makers.

In describing the cow-farms, the breed of cattle kept on them has been mentioned; there are few others kept, except on the pleasure grounds of gentlemen. Indeed the quantity of live stock in Middlesex is probably less than in any other county, in proportion to the number of acres. Few sheep are kept, and those principally for breeding house and grass lamb. The farm-horses are of a large size, of the Leicestershire breed. At the time when there were more distilleries in the county than there are at present, many hogs were kept and fattened at them; but now there are comparatively few in Middlesex.

There are few manufactures, except in London and its immediate vicinity; and these have been noticed in our account of the metropolis. In this article, however, it may be proper to notice more particularly the manufacture of bricks. These are made in all directions round London, but chiefly from the strong loam near Islington, Kingsland, and Hackney. Upwards of 2000 acres have been dug to the depth of from 4 to 10 feet for brick earth; and each acre is calculated to have paid, on an average, £4000. The sum usually paid to the owner of the soil for an acre is £100. The brick earth is mixed with coal ashes and sand; and the bricks are burnt partly by the ashes they contain, and partly by ashes strewed among the layers of bricks in the kiln. Gravel is another very profitable article derived from the ground, it being the material exclusively employed in making and repairing the roads; hence they are very dusty in summer, and very deep and heavy in winter; and were it not that the county is so flat, they would be very inconvenient for carriages and waggons. Middlesex is intersected by the three most frequented turnpike roads in the kingdom, namely, the great western road, the great northern road, and the road into Essex, Suffolk, and Norfolk. The following are the results of the last return to Parliament on this subject, for the year 1814.

	Miles.
Length of paved streets and turnpike roads, - -	304
Length of all other highways on which carriages go, -	667
Total,	971

Estimated value of the labour employed in these roads,	£3045
Composition money - - - - - -	11713
Money expended in law-suits, &c. - - -	466
Total,	£15224

or at the rate of about £100 a mile.

Besides the London markets, the principal markets in Middlesex are at Uxbridge, Barnet, Hounslow, &c. That at Uxbridge is one of the greatest corn-markets in the kingdom; and that at Hounslow generally presents a considerable number of fat cattle.

The following are the results of the last returns to Parliament, respecting the poor rates and other parochial rates of this county, for the year 1815.

Annual value of real property in 1815 -	£5,595,536	0	0
Poor and other parochial rates - - -	675,167	0	0
Average rate in the pound - - - -	0	2	5
Money expended in the maintenance of the poor	505,601		
Money expended in suits of law, removals, &c. -	24,099		
Money expended for militia purposes - - -	10,258		
Money expended for church-rates, county-rates, &c.	153,396		
Total money expended - - - -	£693,354		
Number of poor supported out of workhouses -	18,241		
Number of poor supported in workhouses -	16,026		
Number occasionally in and out of workhouses -	83,988		
Total - - -	£118,255		
Members of friendly societies - - -	£67,186		
Amount of charitable donations for parish Schools -	£6,251		
Amount of charitable donations for other purposes,	17,447		
Total - - -	£23,698		

On an average of three years, viz. 1813, 1814, and 1815, it appears that out of 207 parishes or places, 177 maintained the greater part of their poor in workhouses; that 12 in every 100 of the population were relieved; that the rate amounted to 13s. 11d. per head; and that the average expence of keeping each pauper amounted to £4, 9s. 5d. annually; that $\frac{1}{28}$th of the money raised is expended in rents of land—$\frac{1}{43}$d for the militia; the total, independent of the poor, between $\frac{1}{3}$d and $\frac{1}{4}$th; and that $\frac{1}{3}$d in every hundred were members of friendly societies. The following comparative details are also important:

	Parochial Rates.	Expended for Poor.
In 1776, - - -	£89,108	£79 090
Average of 1783-4-5, -	102,874	89,383
In 1803, - - - -	490,144	349,200
Average of 1813-14 15, -	663,103	517,300

The members of friendly societies in 1803, were more numerous than in 1815; in the former year there having been 72,741, whereas in the latter there were only 67,186.

The following are the results of the last returns respecting the population. In the year 1700, there were 624,200; in 1750, there were 641,500; in the year 1801, 845,400; and in the year 1811, 953,276, or 3380 persons in a square mile. There is one baptism to 40 persons; one burial to 36; and one marriage to 94. The following table exhibits the baptisms, burials, and marriages, from 1801 to 1810 inclusive.

	Baptisms.	Burials.	Marriages.
Males -	115,237	105,195	
Females -	114,174	101,609	100,774
Total	229,411	206,804	100,774

Houses inhabited in 1811 - -	130,613
Families occupying them - -	222,010
Houses building - - - - -	2311
Houses uninhabited - - - -	4326
Families employed in agriculture - -	9038
Families in trade - - -	135,398
All others - - - -	77 524
Males - - - - -	434,633
Females - - - - -	518,643
Total - - -	953,276
In 1801 - -	845,400
Increase - - -	107,876

See Middleton's *Survey of Middlesex*; Lyson's *Environs of London*. (w. s.)

MIDDLETON, Conyers, an eminent English divine, was born at York, in the year 1683. His father, the Rev. William Middleton, rector of Hinderwell, near Whitby, gave him a liberal education, and at the age of seventeen, he was admitted a pensioner of Trinity College, Cambridge, and two years after he was chosen a scholar on the foundation He took his degree of A. B. in 1702, and officiated as curate of Trumpington, near Cambridge. In 1706, he was elected a fellow of his college, and next year he became A. M. About two years afterwards, he married Mrs. Drake, a widow of ample fortune; and, after his marriage, he took a small rectory in the Isle of Ely, which he resigned, however, in little more than a year, on account of its unhealthy situation.

When George I. visited the university of Cambridge, in the month of October 1717, Middleton, along with several others, was created a doctor of divinity by mandate; and he took an active part in the famous proceeding against Dr. Bentley, which for some time occupied much attention. In that controversy, in the course of the year 1719, he published the following four pieces: 1. "A full and impartial Account of the late Proceedings in the University of Cambridge against Dr. Bentley," &c. 2. "A Second Part of the full and impartial Account," &c. 3. Some Remarks upon a Pamphlet, entitled, the Case of Dr. Bentley farther stated and vindicated," &c. 4. "A true Account of the present State of Trinity College, in Cambridge, under the oppressive government of their master, Richard Bentley, D. D."

When, in 1720, Dr. Bentley published his "Proposals for a new Edition of the Greek Testament, and Latin version," Middleton, the following year, published "Remarks, paragraph by paragraph, upon the Proposals," &c. Bentley defended his Proposals against these Remarks, which, however, he did not ascribe to Middleton, but to Dr. Colbatch, a learned fellow of his college, and casuistical professor of divinity in the university, for the double purpose, it is supposed, of giving him an opportunity of abusing Colbatch, and of shewing his contempt of Middleton. At a meeting in February 1721, the vice-chancellor and heads of the university pronounced Bentley's book to be a most scandalous and malicious libel; and they resolved to inflict a proper censure upon the author, as soon as he should be discovered. Middleton then published, with his name, an answer to Bentley's defence, entitled "Some farther Remarks, paragraph by paragraph," &c. These two pieces against Bentley are written with great acuteness and learning.

Upon the great enlargement of the public library at Cambridge, the office of principal librarian was conferred upon Dr. Middleton, who, to shew himself worthy of it, published, in 1723, a small piece with the title, *Bibliothecæ Cantabrigiensis ordinandæ quædam, quam domino procancellario senatuique academico considerandam et perficiendam, officii et pietatis ergo proponit.* In the dedication of this tract to the vice-chancellor, in which he alluded to the contest between the University and Dr. Bentley, he made use of some incautious expressions against the jurisdiction of the Court of King's Bench, for which he was prosecuted, but dismissed with an easy fine.

Soon after this publication, he had the misfortune to lose his wife, and having fallen himself into bad health, he undertook a journey through France and Italy, along with Lord Coleraine, and arrived at Rome early in 1724. He was at Paris towards the end of the year 1725, and arrived at Cambridge before Christmas. Shortly after, he published a tract, entitled *De medicorum apud veteres Romanos degentium conditione dissertatio; qua contra viros celeberrimos Jacobum Sponium et Richardum Meadium, servilem atque ignobilem eam fuisse ostenditur;* which drew upon him the displeasure of the whole medical faculty, particularly of Dr. Mead. Middleton defended his dissertation against various attacks in a new publication, entitled *Dissertationis, &c. contra anonymos quosdam notarum brevium, responsionis, atque animadversionis auctores, defensio, Pars prima.* 1727. Mead and Middleton afterwards became very good friends. A *pars secunda*, however, was actually written, and printed for private circulation, after Middleton's death, by Dr. Heberden, in 1761, 4to.

In 1729, Middleton published "A letter from Rome, shewing an exact conformity between Popery and Paganism; or, the religion of the present Romans derived from that of their Heathen ancestors." In this letter, he gave offence to some of the English divines, by attacking the Popish miracles with that general spirit of scepticism and levity, which seemed to condemn all miracles. In the second edition, he endeavoured to obviate this objection, by an express declaration in favour of the Jewish and Christian miracles. To the fourth edition, which came out in 1741, 8vo. were added, 1. "A prefatory discourse, containing an answer to the writer of a Popish book, entitled "The Catholic Christian instructed," &c. and 2. "A Postscript, in which Mr. Warburton's opinion concerning the Paganism of Rome is particularly considered."

Upon the publication of Tindal's famous book, called "Christianity as old as the Creation," many writers entered into controversy with its author; and, among others, Waterland, who wrote "A Vindication of Scripture," &c. Middleton, being displeased with Waterland's manner of vindicating Scripture, addressed "A Letter" to him, in 1731, containing some remarks on it, together with the sketch or plan of another answer to Tindal's book. He did not, however, put his name to the tract; nor was it known for some time, who was the author of it. Waterland having continued to publish more parts of "Scripture vindicated," &c. Pearce, bishop of Rochester, took up the contest in his behalf; which drew from Middleton "A Defence of the Letter to Dr. Waterland against the false and frivolous cavils of the author of the Reply," 1731. Pearce replied to this defence, and treated Middleton, as he had done before, as an infidel, or enemy to Christianity in disguise. Middleton, who was now known to be the author of the Letter, was, in consequence, very near being stripped of his degrees, and deprived of all his connections with the University. But this was deferred, upon a promise that he would make all reasonable satisfaction, and explain himself, if possible, in such a manner as to remove every objection. This he accordingly attempted to do, in "Some Remarks on Dr. Pearce's Reply." He also published, in 1733, "Some Remarks," &c. on an anonymous pamphlet, entitled "Observations addressed to the author of the Letter to Dr. Waterland," which was written by Dr. Williams.

During this controversy, Middleton was appointed, in December 1731, Woodwardian professor, being the first appointed by Woodward's trustees. In July 1732, he published his inauguration speech, with this title, *Oratio de novo physiologiæ explicandæ munere, ex celeberrimi Woodwardi testamento instituto habita: Cantabrigiæ in scholis publicis.* This situation, however, he resigned in 1734, when he was made principal librarian.

In 1735, he published "A Dissertation concerning the origin of Printing in England," &c. in which he endeavoured to prove that this art had been introduced by Caxton. In the year 1741, appeared Middleton's great work, "The History of the Life of M. Tullius Cicero," in 2 vols. 4to. The profits of this work enabled him to portion two nieces, and to purchase a small estate at Hildersham, about six miles from Cambridge. In 1743, he published "The Epistles of M. T. Cicero to M. Brutus, and of Brutus to Cicero," &c. in which he vindicated the authority of these epistles against the objections of the Rev. Mr. Tunstall. In 1745, he published *Germana quædam antiquitatis eruditæ monumenta, quibus Romanorum veterum ritus varii, tam sacri quam profani, tum Græcorum atque Ægyptiorum nonnulli, illustrantur*, &c. 4to.; and in 1747, "A Treatise on the Roman Senate," in two parts.

In the last mentioned year also, a publication appeared, which laid the foundation of another controversy with the clergy. This was his "Introductory Discourse to a larger book, designed hereafter to be published, concerning the miraculous powers which are supposed to have subsisted in the Christian church from the earliest ages, through several successive centuries," &c. This introductory discourse was immediately attacked by two celebrated controversial writers, Dr. Stebbing and Dr. Chapman; and Middleton replied by "Some Remarks" on both their performances. In December of the same year, he published his larger work, with this title, "A Free Inquiry into the miraculous powers which are supposed to have subsisted in the Christian Church," &c. Innumerable antagonists now appeared against him, among whom Dodwell and Church distinguished themselves so much, that they were complimented by the University with the degree of D. D.

Meanwhile, Middleton surprised the public with "An Examination of the Lord Bishop of London's Discourses concerning the use and intent of Prophecy," &c. which was refuted by Dr. Rutherforth, divinity professor at Cambridge. While meditating an answer to all the objections made against the "Free Inquiry," he was seized with a slow hectic fever and disorder in his liver, which terminated his life, at Hildersham, on the 28th of July, 1750, in the sixty-seventh year of his age. He left no children by any of his wives.

In 1752, were published the miscellaneous works of Middleton, containing all those above mentioned, with the exception of the Life of Cicero, and several tracts which had not been published during his life. A second edition of these miscellaneous works was afterwards published in five volumes octavo.

Middleton was undoubtedly a man of great talents, learning, and industry; and in controversy he was a very formidable antagonist. But neither the principles he proposed, nor the style and tone of his polemical tracts, do much credit to his judgment and temper. None of his works are now much read, except his Life of Cicero, which is certainly a very valuable production, although written too much in the language of panegyric. (z)

MIDWIFERY.

Midwifery strictly signifies the art of delivering women; but it is now universally understood to include also the physiology and pathology of the pregnant and puerperal states, and a knowledge of the management of infants and children, both in health and disease.

The term, in the English language, is derived from the two Saxon words signifying *mead* and *wife*, the midwife being the woman who got a present or gift for accomplishing the delivery. The old Scotch term for midwife is *howdie*, supposed to be derived from the Saxon word signifying childbirth.

The French name their midwives, from their reputed skill, *sages femmes;* whilst the art itself is styled, from the confinement of the patient, *L'art des Accouchemens.* In all ages, and in every country, the practice has been generally in the hands of females; and both in ancient and modern language the appellation of the practitioner is always feminine, with the exception of the French term *accoucheur.*

By the Roman law, midwives were recognised as a distinct class in society, and partook of certain immunities and advantages in common with medical practitioners. At the present time, in several continental countries, no one can practise midwifery without a license; but in Britain it is otherwise, as every one who chooses to run the risk incurred by common law for the fruits of ignorance, may practise as a midwife. With regard to accoucheurs, they stand in this peculiar state, that they sometimes are considered as belonging to medicine, and sometimes to surgery. With the exception of a temporary measure adopted by the College of Physicians in London, no public body has issued distinct licenses to male practitioners. In some German universities, it is explicitly attached to the united degree of doctor of medicine and surgery. In others, it seems indifferently to belong to the doctor of medicine or master of surgery. In the university of Glasgow, the only one in Britain which confers surgical degrees, the right to practise midwifery is included in the degree of magister chirurgiæ.

Historical Sketch of the Progress of Midwifery.

It would be quite impossible, in a work of this kind, to trace the history of midwifery minutely through every individual who has written on the subject, from Hippocrates downwards. Even to a medical reader, this would be more a matter of curiosity than utility. It appears from the early writers whose works we possess, that in natural labour the patient was placed on a particular kind of seat or stool, and the process of delivery conducted altogether by the midwife, who, we may presume, from little being said of her duty, had no very difficult office to perform. It was only in cases of protracted labour, or in those where the child could not be born, either on account of its position, or size compared with the pelvis, that the male practitioner was called; and at this place it may be observed, that Paulus Ægineta, in the 7th century, seems to be the first who was styled a man midwife. The practice adopted in such cases, no doubt varied a little at different times, and in different hands; but the general principles of conduct were not much diversified, and may be learned by consulting the works of Ætius, Albucasis, and Avicenna. In tedious labour, the effect of concussion was sometimes tried to promote delivery; but it was more common to employ means for producing relaxation, such as emollient applications, and even the warm bath. Bloodletting, so useful in many cases of tedious labour, was strongly recommended by Hippocrates; and it is much to be regretted, that his authority in this respect has been so long slighted by the moderns. Those, on the other hand, who seemed to be too much enfeebled, were ordered to be sprinkled with vinegar, or to sit over vapours supposed to have a strengthening quality.

In preternatural positions, the presentation was either pushed back, and the head made to come forward; or, the protruding member was twisted off, and the child pulled away piecemeal. When the head was large, or the pelvis small, various modes were adopted. The head, by some, was pushed back, if not impacted, and the child turned, so as to allow the practitioner to deliver by the feet. This continued long to be the resource in all cases where it was practicable, as there was thus a possibility of saving the child. But if the obstacle were considerable, the infant always perished, and, in many cases, the body was actually torn away from the head. This accident in aftertimes gave rise to different contrivances for extricating the head which thus remained in the uterus. Other practitioners, at a very early date, endeavoured to deliver the child by fixing a fillet or band around the head, thereby becoming able to pull it down. In a greater number of instances, however, they accomplished delivery by opening the head, or fixing a hook or crotchet into it, or squeezing it in forceps furnished with teeth.

From the seventh down to the sixteenth century, various writers are to be met with, but little improvement is to be found in the art. The most popular work in the sixteenth century, was published originally in German by Eucharius Roesslin, commonly called Rhodion. This, which was entitled the *Garden of Lying-in Wo-*

men and Midwives, was translated into Latin and all the modern languages, and became the code of instruction for midwives. It was not possible for rapid improvement to be made, the women could not go beyond their teachers, and their teachers had few means of instructing themselves by actual practice. Dr. Veit, in 1522, was publicly branded in Hamburgh, for having been present at a delivery under the disguise of a midwife.

In the sixteenth century, when little originality was to be met with, Ambrose Paré formed an exception to the general character of the age; and it is this circumstance which has made him stand higher in public estimation than his real merits deserve. Yet it is far from the intention of the writer of this article to detract from his claim; for surely the man, who, in an age of darkness and servitude, can to any degree desert the beaten path for a better way, is entitled to more praise than the author of a brilliant system in a period enlightened by science and philosophy. Paré was the best surgeon of his day, and his book, in many respects, bears the same relation to medical details that Froissart's chronicle does to a dry history. His obstetrical directions are to be found in his general work, but came again before the public in a separate form by his pupil Guillimeau. This contained a view of all that was known at the time; but its chief merit, and the ground of Paré's obstetric reputation, is the rule, which he rendered nearly absolute, in all preternatural labours to turn the child, and deliver by the feet. This work was succeeded, in 1668, by a system of F. Mauriceau, who not only had much private experience, but opportunity of improvement in the Hotel Dieu, part of which by this time had been appropriated to lying-in women, and is to be considered the first establishment of the kind in Europe. His book is not only worthy of notice from its merit, considering the time when it appeared, but also from the English translation by Dr. Chamberlain, containing an intimation in the preface that his father, himself, and his brother, possessed a mean of delivering women in difficult labour in a way compatible with the safety of the child. How long his father or the family had possessed the secret is not known, but the first public intimation is given in the preface alluded to, which appeared in 1672 Before this he had gone over to Paris with the intention of selling his secret, but imprudently boasted that he could deliver safely a woman whom Mauriceau had declared could not be saved otherwise than by the Cesarean operation. The result of his trial, in this case, was such as might have been expected, and, instead of selling his secret, he, by promising too much, lost his reputation, and with empty pockets returned to England. Next he went to Holland, where he communicated at least part of his secret to Roger Roonhuysen, from whom it passed to Ruysch and others as a nostrum; nor was it revealed till 1753, when De Vischer and Van de Poll purchased it, and made it public. It was long afterwards in repute under the name of the Lever; but has now deservedly lost ground. It would appear that Chamberlain used both the lever and the forceps; but whether he only revealed the former to Roonhuysen, or had not then employed the forceps, is uncertain, and unimportant in the annals of quackery. Of late, a discovery has been made of the original instruments, in an old building in Essex, where, in the floor of a closet, a door was perceived with hinges. This being opened—not by Mrs. Radcliffe, but by a sober matter-of-fact-man—there was found neither blood-stained armour, nor mysterious parchment, but some rusty instruments of three different descriptions, a lever and two pair of forceps, one a little more improved than the other. Soon after this time, other practitioners, both in Britain and on the continent, employed similar instruments; but it was not for many years afterwards that a description of them was made public. Dr. Denman, in a very desultory historic sketch which he prefixed to his work, and which is altogether unlike that work, says, that Dr. Chapman first described the forceps in the *Edinburgh Medical Essays*, in 1733; but he cannot have read these essays, for it is Mr. Butter who there gives a plate of the instrument he had seen in Paris, whilst in the end of the volume Chapman is criticised for not depicting his forceps. This he afterwards did. He is reported to have been the second person who taught midwifery in this kingdom. Maubray, about ten years before, had started for the first time as a lecturer; but is chiefly known for his opposition to the use of instruments.

Soon after Chapman taught, Dr Smellie came forward, and gained deserved reputation both as a practitioner and teacher. He published, 1752, a system, which, although unimportant now, was long the elementary work consulted by all students, and to this he afterwards added two volumes of cases, and one of plates. He gave distinct rules for using the forceps, which he improved in their construction. He did not, however, carry their utility far enough; for he is found still advising the old mode of turning when the head is not fixed. In his class he made considerable use of machines; and, if we may credit his enemy Dr. Douglass, he endeavoured to condense his information, so as to suit all purses as well as all capacities; for he is said to have hung out a paper lantern with these words, "Midwifery taught here for five shillings"

About the same time, Levret, in Paris, acquired high reputation, not only for his description and improvement of the forceps, but for his general knowledge of midwifery. His observations on uterine hemorrhage, considering the state of science at the time, are admirable and important. Accoucheurs have made a distinction of floodings into those arising from detachment of the membranes, or part of the placenta which is properly situated, and those produced by the placenta being attached in a greater or less degree to the os uteri. In the former case, Puzos advised the membranes to be ruptured, in order to excite contraction of the womb. In the latter, Levret decided that nothing but delivery could be useful. By blending these two works, Rigby afterwards compiled a treatise on the subject; but the opinion now of every judicious practitioner is, that in all cases of flooding requiring manual interference, that ought to consist in delivering as soon as it can safely be accomplished. This is a subject of very peculiar importance, and it is necessary that the practitioner make himself well acquainted with the principles of conduct, and act with promptitude and decision.

Dr Hunter appeared also on the field about the same time; for he came to London in 1741 His talents, his general learning, his professional knowledge, his zeal and industry, together with a good manner, introduced him into extensive practice. His obstetrical works consist of the anatomy of the gravid uterus, illustrated with very splendid plates, and a description of the retroversion of the womb. He added to his anatomical lectures a few on midwifery, which, it is much to be feared, have done essential injury to the profession and the community. Patience was his advice in most cases, and an almost unbounded reliance on the power of nature formed the basis of his practice. That much good sprung from his admonitions to avoid irritation, and the use of stimulants in natural labour, is unquestionable. But it is equally true, that, when assistance is necessary, patience becomes another name for negligent procrastination. It is not to be credited how many women and children are lost by too great reliance on the power of nature, and a reprehensible delay in having recourse to the assistance of art; and with the highest respect for the memory of Dr. Hunter, the writer of this article remains convinced, that his authority contributed greatly to introduce and support that passive conduct which is too often pursued in protracted labour. The directions of the late Dr. Osborn on this subject, which sprung from the school of patience, cannot be read without astonishment, and the deepest regret; and the consequence of this system of delay is and must be, that in many instances, although the child be at last expelled, it is born dead, and the mother soon follows; or instruments are at last used, when they are less likely to save both parties than if they had been employed earlier, whilst, in all, the patient suffers more pain by this supine conduct, than she would have done by more vigorous practice.

It unfortunately happens, that in some instances the pelvis is so contracted or deformed, that by no method can a living child be brought through it. In such cases four different methods have been proposed: 1*st*, To open the head, and fix a hook or crotchet on it, and then draw down the child. 2*d*, To make an incision through the skin and muscles into the womb, and thus extract the child alive. This is called the Cæsarean operation. 3*d*, To divide the joining of the bones of the pelvis in front, and thus endeavour to enlarge the cavity through which the child must pass. 4*th*. To induce premature labour. It is not necessary to enter here into any critical examination of the comparative merits of these different methods. It may only be observed, that the chief point of controversy is, whether the crotchet or the Cæsarean operation should be preferred. In this country the former is always resorted to, when possible, and the latter is only performed in extreme cases. These, it may therefore be expected, can seldom prove successful; and, as if the condition of the patient were not a sufficient source of danger, it is seldom performed till she has been some time in labour, and perhaps considerably exhausted. This has arisen from the same cause which has been already so strongly reprehended. It surely may be early ascertained in such extreme cases, that the pelvis is too small to permit of delivery by any means through it; and delay, after this is known, is adding to the hazard of an operation which requires no additional risk to render it formidable. This delay has greatly arisen from the arguments and statements of the late Dr. Osborn, who maintained that no case of deformity so great could occur as would prevent the extraction of the child by the crotchet. In proof of this, he published a case where the operation proved successful in extreme contraction. The fallacy of his reasoning was very ably shewn by the late Dr. Hamilton, whilst Dr. Johnston experimentally proved, that it was impossible to bring a mutilated child through an aperture cut in a piece of wood exactly of the dimension of the pelvis described by Dr. Osborn, who consequently must have been deceived. It is of great importance to humanity to have this point ascertained; for, although every British practitioner prefers the crotchet to the Cæsarean operation, yet, if it be conceded that in some cases the former cannot be employed, it follows that in such cases the sooner we resort to the operation, the more likely it is to be successful. It has almost uniformly been fatal in this country, but often successful on the Continent. This must arise either from its being performed earlier there, or on more favourable subjects. If in this country we perform it only on the most deformed and unhealthy, it is our duty to these sufferers not to increase their danger by delay, in the senseless expectation of being able to accomplish a physical impossibility.

To carry this sketch of the progress of midwifery farther, or extend it to the diseases of women and children, would exceed the limits proper to a work of this kind. To notice all the eminent writers and teachers of the present day would be impossible, and to make a selection where so many are to be found, would be both difficult and invidious.*

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* In noticiog the rise and progress of obstetric science in the United States of America, we have to mention with respect the name of Dr. William Shippen, who, after having enjoyed the advantages of a most liberal medical education in Europe, and sedulously cultivated anatomy, surgery, and midwifery, under the immediate direction of the celebrated Dr. William Hunter, upon returning to his native country, gave the first public lectures on these branches of medical science io Philadelphia, in the year 1762, and continued for many years to practice midwifery very extensively. His lectures on this subject, though few in number, may be said to have embraced the leading principles of the art, which he illustrated on a machine, probably the first of the kind which had ever reached these shores.

The science of obstetrics is now considered as a necessary part of medical education in this country, and is regularly and fully taught in the universities aod medical institutions in the United States, by professors appointed for that express purpose. Several interesting works on this branch of medical science have also been published by practitioners of respectability, tending much to the improvement of an art, which may be justly considered as essential to the prosperity of every community. We may be allowed to state, that the treatment of puerperal women generally, if the bills of mortality are to be relied on, has been more successfully conducted in the United States than in Great Britain.

In proof of this we may mention the ioformation from an intelligent author, (Dr. Merriman,) that on examining the bills of mortality in London, it appears that the average number of deaths in childbed, for ten years towards the close of the 17th century, was in the proportion of 1 to 39, while, for the same number of years, at the commencement of the present century, it was only in the proportion of 1 to 106.

But upon torning our attention to the United States, and particolarly to the "Statement of Deaths in the City and Liberties of Philadelphia," for the last eleven years, endiog the 1st of January, 1818, it appears that the number of women dying in childbed, when compared with the whole number of deaths, is only as 1 to 419.

It must notwithstanding be confessed that, not baving the London bill of mortality to refer to, there may remain some uncertainty, whether the deaths from puerperal fever are included under the head of *Childbed*, but even should that be the case, the number of deaths onder the heads of *Childbed* and *Puerperal Fever, taken conjointly*, and occurring for the last eleven years in Philadelphia, is only in the proportion of 1 in 178. J.

Part I.—OF THE PREGNANT STATE.

CHAP. I.

Of the Gravid Uterus.

The first visible change produced on the uterus and ovaria by conception, is increased vascularity. Simultaneous with this is an augmentation of the bulk of the womb, or enlargement of its cavity, and a secretion within that cavity. The cervix uteri is filled with inorganic jelly, whilst the fundus and body are lined with a coating consisting partly of lymph, and partly of vessels. This has been called the membrana decidua, and is formed before the ovum can be detected in the uterus. Whilst a receptacle is thus preparing for the child, changes are going on in the ovarium, where the ovum first appears. This becomes more vascular, and at one part a small vesicle becomes prominent. The exterior covering of the ovarium seems at this part to be absorbed, whilst the fimbriated extremity of the tube adheres firmly over it, and receives the vesicle or ovum, as it is extricated from the ovarium surface, conveying it down into the uterus itself, whence it is to be developed. That part of the ovarium whence the embryo has issued, undergoes certain changes in appearance, forming a distinct substance, known under the name of corpus luteum, the presence of which is considered as an indication of conception having at one period or other taken place. At a very early stage, several vesicles may be discovered under the covering of the ovarium, at least the writer has observed this in two or three instances, but whether these be ova which fade, is not determined. The ovum, from the earliest time when it can be examined, consists of two vesicles, one within the other. The innermost is much smaller than the outermost, but is connected with it at one spot. The internal contains a little transparent fluid, and the minute embryo. The space between the two vesicles is filled with clear jelly, like the vitreous humour of the eye, and the outer surface of the external vesicle is covered with small vessels, which in a short time increase so much that they form a distinct vascular covering, known under the name of the spongy chorion, whilst the vesicle they cover is called the membranous chorion: the vesicle within both is called the amnion, and the fluid it contains, and which is in immediate contact with the embryo, is named the liquor amnii. For a considerable time after the ovum enters the uterus, the chorion and amnion, except at one point, are far distant from each other, but presently the amnion enlarges more rapidly, so as to fill the space enclosed by the chorion, and the intervening jelly is absorbed in the same proportion. In common language, the embryo is said to be within these membranes, but anatomists know well that it is exterior, as the bowels lie without the peritoneum For it is next to be noticed, that at one part, namely, where the embryo is situated, a small prolongation of both membranes is turned inward, so as to form a short tube, along which vessels run from the spongy chorion to the embryo, and from the embryo to the chorion. This prolongation is afterwards called the umbilical cord, and the passing vessels the umbilical vessels. When the ovum enters the uterus, it does not pass down unconnected through the tube, nor fall loosely into the uterine cavity, but, arrived at the end of the tube, and entering the womb, it meets with the decidua vera, as it has been called, and an intermixture of vessels takes place between the chorion and decidua, and in proportion as the ovum expands and fills the cavity, the decidua expands or grows with it; affording a covering, until it grows so large as to fill the cavity. This expansion of the decidua has received the name of decidua reflexa, and it becomes thinner and more gelatinous as pregnancy advances. It has been already stated, that the embryo sends vessels which ramify over the chorion, and part of which there unite to the decidua reflexa; but at that part where they pass out from the embryo, they are more numerous than elsewhere, and unite with the decidua vera, and form a thick vascular cake called placenta, which consists thus of two portions, one formed by the womb, and one by the fœtus, and it serves as the intermedium between them, and the source whence nourishment is derived, and a substitute for the lungs in the fœtal circulation. To be more minute on this subject is not consistent with the plan of this work.

It is uncertain at what time the ovum enters the uterus. Dr Haighton could not detect it in the uterus of the rabbit earlier than from the fourth to the sixth day. Now, in that animal the period of uterogestation is only 30 days; from analogy, which doubtless is not to be held as proof, one would not expect to find it early in women, who go so much longer. Some microscopic observers have supposed that they saw the embryo eight days after conception; but, be this as it may, it cannot be detected with the naked eye for much longer. It is not probable that the ovum can be seen in the uterus until nearly three weeks after conception. In an instance where the conception could not be less than five weeks, the membranes were of the size of a small chesnut, and the fœtus scarcely so large as an ant. In the sixth week it is curved, forming a bulk like a split pea. In the seventh as large as a bee. In the eighth, about the size of an ordinary bean. At first the embryo consists merely of two oval bodies joined together, which are the rudiments of the head and trunk; then the extremities sprout out like buds, and the different organs become gradually developed. At the full time a male child measures about twenty inches, and the average weight is seven pounds.

At first, from the increased weight, the uterus subsides in the pelvis, at the same time that the os uteri becomes more circular, instead of transverse, as formerly. In course of time, however, it becomes so large that it can no longer remain sunk in this situation, but rises above the brim of the pelvis. The time at which this happens must depend to a certain degree on the capacity of the pelvis, and the enlargement of the uterus It usually happens in the end of the fourth month, that is, after 16 weeks from conception, but it may be earlier, and is often somewhat later. This elevation takes place in general rather suddenly, and in many cases the sensation occasioned by the rising of the uterus is very well marked, and sometimes accompanied with fainting, or hysterical symptoms. This is confounded by many with the motion of the child itself, which is felt about this time, and the person is said now to quicken. It is quite absurd to suppose, that before this the child is not alive, and does not move. The motions are now felt, because the child is stronger and larger, compared to the quantity of liquor amnii, and the uterus is in a more sensible situation. Lawyers, however, who are in general bad physiologists, have decided that it is murder to procure abortion after the time of quickening, but a minor offence to do so earlier. If any doubts have existed respecting the existence of pregnancy, they are at this period cleared up; for the patient herself is sensible of the motion, and the accoucheur, by examination *per vaginam*, feels the uterus to be heavy, and when pressed up with the finger, there is perceived the *mouvement de ballotement:* and by gently striking the under part of the uterus once or twice, the fœtus is perceived distinctly to move or flutter within.

It requires nine months to bring the human fœtus to perfection, and experience teaches many women, from particular feelings, how to judge pretty accurately with regard to the time when they are to be confined. When there is no particular circumstance to guide them, the general way is to calculate forty-two weeks from the last period of menstruation, forty weeks being the term of gestation. This determines within a fortnight, and farther assistance is derived from attending to the time of quickening. Many bring forth before the full time, but it is rare to go beyond the ordinary time; but it is certainly possible to do so.

Children born in and after the seventh month may live, but the nearer they approach to perfection, the more likely are they to thrive. If they have no hair nor nails, and the skin be not red about the palms of the hands, breast, and scrotum, and if they can neither cry nor suck, there is no chance of their living. Instances, however, have occurred, where children in the sixth month have been kept alive, by being fed and kept warm.

CHAP. II.

Of the Signs of Pregnancy.

Although some women very early begin to have complaints, or to experience certain sensations which apprize them of conception having taken place, yet in general the first indication of pregnancy is the interruption of the menstrual action. It has been a question for discussion amongst medical men, whether the menses have ever continued to appear regularly during pregnancy, and, notwithstanding the different instances which have been brought forward to the author, he is still convinced that the two conditions are so incompatible with each other, that regular menstruation is inconsistent with pregnancy. It is placed beyond all doubt, that many women have had periodical discharges during part or the whole of pregnancy; but these, from the attendant circumstances, are rather to be viewed as hemorrhages than as a continuation of the natural secretion. Yet Baudeloque, Chambon, and other respectable men, have told us of instances, where women did not menstruate except during gestation.*

The breasts very early sympathise with the uterus. It is not unusual for them at first to become a little smaller, but by the third month there is an evident enlargement, and the nipple presently becomes surrounded with a brown areola. The augmentation of size is slower of taking place in those who are delicate, or who have sanguineous evacuations from the uterus during the early months of pregnancy. A serous or milky fluid also is secreted, and either flows from the nipples, or can be pressed out.

It is not unusual for the abdomen, soon after conception, to become flatter than formerly, and continue so for a month or two, after which it enlarges. In other instances it very early increases in size, chiefly from a distended state of the bowels. In pregnancy the tumour is most manifest below the umbilicus, which generally becomes prominent towards the sixth month, if not sooner.

It is possible, but not usual, for all these symptoms to appear in the virgin state, in consequence of uterine irritation; but much more frequently they arise, if not from true pregnancy, at least from a blighted ovum, or what has been called a false conception. Many women, who have had a large family, when they advance in life, are liable to inflation of the abdomen, and irregularity of the menstrual discharge, occasionally accompanied with slight changes in the appearance of the breasts. They are willing to believe themselves not past the age of childbearing, and fancy they feel the motion of the child; but it is only wind passing along the bowels, and is known to be so by shifting its place, and generally being perceived higher than the uterus.

These signs, with the existence of what have been called the disorders of pregnant women, do, in the married state, justly warrant the belief of the existence of pregnancy; but we cannot arrive at certainty until the time of quickening, or by examination *per vaginam*, about that period. Earlier, even this mode cannot positively decide the question, for the womb may be enlarged by other causes. Still it affords in the third month strong presumptive evidence.

CHAP. III.

Of the Disorders incident to the Pregnant State.

It is not to be expected that the uterus can undergo the great and active changes which it experiences after conception, without affecting to a greater or less degree the whole frame, and particular organs. The general sympathy which exists amongst the different parts of the body, as well as the particular influence which individual systems and viscera exert on one another, render it impossible for one part to have its action materially altered, increased, or diminished, without producing more extensive effects.

* In these cases, the secretion of the menstrual fluid is most probably from the cervix and the immediate vicinity of the os uteri, otherwise the ovum, in the early stages of pregnancy, must necessarily be detached and carried away by the discharge.

The effects produced by the gravid uterus may be classed under the following heads: 1*st*, Those which arise from the sympathy of particular parts with the uterus, some of which have their activity increased, others diminished. Examples of these we have in the changes produced on the breasts and stomach. 2*d*, Those which proceed from more general sympathy, as we see exemplified in the nervous and vascular systems. 3*d*, Those which are occasioned chiefly by a mechanical cause, as œdema of the feet, and swelling of the veins. Few, if any, of these effects, however, can be said to arise purely and entirely from one class of causes. They may be individually referable to one or other class chiefly, but the causes themselves are so interwoven and mixed up with one another, and there are so many reactions, that the classification must be taken with circumspection, and a latitude allowed.

From the brisk and increased action which goes on in the uterus, so long as gestation continues, and the ovum thrives, we find that a change takes place in the state of the blood. It does not assume an inflammatory appearance, but it becomes sizy, an effect not peculiar to pregnancy, but produced by many other local irritations. The arterial system is likewise excited, so that the pulse becomes sharper, sometimes stronger, and generally, in the commencement of pregnancy, variable. The functions dependent on the blood-vessels are also influenced; animal heat is often increased, the deposition of fat, and perhaps of other constituent parts of the frame, is either actually lessened, or the process of absorption is increased, or both of these take place; for in general the female becomes thinner. Yet there is rather a redundancy than a deficiency of blood, for plethora is apt to exist during pregnancy In many cases these effects appear only in a moderate degree; in other cases, however, the patient is actually feverish, sleeps almost none, and becomes extremely emaciated. As this condition, like the other disorders of pregnancy, arises from the state of the uterus, it is evident that, so long as the latter exists, the former must continue; and all we can do is, to mitigate what we cannot cure. This is best done by strict attention to the state of the bowels, taking occasionally the saline julep, avoiding much animal food, every thing of an irritating or heating nature, and even abstaining from all unnecessary quantity of the blandest liquids, sleeping on a firm matress, with no more bed-clothes than are requisite, procuring a free ventilation of air, and detracting blood from the veins, if the symptoms do not yield to this regimen. With regard to exercise, there has been some diversity of opinion; but all must agree, that where there is a tendency to abortion, this must be abstained from altogether, or taken in great moderation, till the period of danger be past. Where there is no cause, however, to forbid it, advantage is very evidently derived from regular, but moderate exercise, taken daily to such extent as does not occasion fatigue. It is partly from the opportunity of taking such exercise with facility, and partly from the salutary influence of pure air on the whole frame, that many patients experience great benefit from spending the period of pregnancy in the country, although inconveniences of a different nature may result from this practice. The stomach and bowels very early are affected by pregnancy, producing sickness, vomiting, heartburn, fastidious appetite, costiveness, or an opposite condition of the bowels, and a train of secondary symptoms ensuing therefrom. When these disorders are in a moderate degree, little requires to be done; and indeed some men of judgment have reasoned themselves into a belief, that, as they arise naturally from pregnancy, we ought not to be very solicitous in removing them. This principle, if followed up, would lead to most absurd as well as dangerous practices in medicine, and, in the present case, would, particularly with regard to costiveness, make us overlook, and indeed encourage a very decided cause of both distressing and formidable disease. Partly from the effects produced by the uterus itself on the nervous system, but still more decidedly by the state of the bowels during pregnancy, many hysterical and anomalous affections are produced, and irregular and painful actions excited in distant parts; and, from the same cause, the brain itself is acted on, and a determination of blood made to the head, which produces severe headaches, convulsions, or apoplexy itself. We are yet ignorant of much which relates to the mutual reaction of the nervous and sanguiferous systems, and perhaps overlook too much the agency of the spinal marrow in many of those severe disorders of the two systems, which have their origin in the state of the abdominal viscera. Nothing tends more to prevent those harassing and often dangerous symptoms, styled nervous, than rigid attention to the bowels. But experience and observation have taught the writer, that when these have actually taken place, particularly if attended with a sense of fulness in the head, much giddiness, or headach of an oppressive kind, or any degree of stupor, that the lancet is the mean chiefly to be trusted. Fashions are not confined to Bond Street, but prevail as much amongst physicians as milliners; and perhaps the present system is to trust too much to the efficacy of purgatives, and too little to the effect of blood-letting.

It is not meant to say that the common hysterical fits which may attack women about the early period of pregnancy, or at quickening, require the lancet, or that these fits, at any period, demand it, unless accompanied with much plethora. They may be overcome by purgatives, light diet, and antispasmodics, aided sometimes by tonics. But there is no fallacy more dangerous than the doctrine, that venesection is improper, merely because the complaint assumes the appearance of hysteria. There are few disorders in the pregnant state, which, when severe, are not relieved by bleeding, unless they evidently are dependent on a state of debility. The very sickness and vomiting of pregnant women are best relieved by this remedy, which subdues the excessive irritation of the stomach; or, if it fail, the application of leeches to the epigastric region is almost certainly beneficial; whilst a general plan is followed for the relief of a systematic condition, particular remedies must be employed for obviating special symptoms: thus heartburn must be removed by antacids, such as chalk or magnesia, combined with ammonia or soda; flatulent pains, by laxatives and carminatives, or antispasmodics; continued sickness, with bitter taste, by very gentle doses of calomel; convulsions, by instantaneous venesection; fainting fits, by cool air, application of cold water, and the use of volatiles; anasarca depending on pregnancy, by the lancet, and aperients, with mild diuretics. To enter more into the detail of the different diseases of pregnancy, would swell this article beyond reasonable bounds; nor, is it necessary, as the general principles of treatment have been freely and without reserve laid down. It will not, however, be proper to conclude this part, without adverting to a mechanical disease, which sometimes takes place between the third and fourth month of pregnancy, and which is known under the name of retroversion of the womb. It may at this period be produced by improper retention of the urine, by which the bladder is distended, the lower part of the uterus raised and brought forward, whilst the upper part is turned back, and thrown down between the vagina and rectum But it is quite a mistake to suppose that retention of urine is the sole cause, or, in many instances, more than a secondary one, of increasing that displacement which had begun to exist. From a careful examination of the progress and symptoms of this disorder, the writer is convinced that frequently it arises from an undue degree of prolapsus. The os uteri is brought lower and more forward than it ought to be, and the fundus lies back in the hollow of the sacrum. The uterus enlarges in this situation, and the fundus sinks lower, whilst the os uteri projects more forward, and obstructs the urine. The bladder becomes distended, and the retroversion is completed or increased thereby, if it had already taken place, by the mere subsidence of the fundus and consequent elevation of the opposite end, the uterus turning to a greater or less extent, like a beam of a balance on its axis. A moderate degree of malposition produces inconvenience, chiefly from the pressure it occasions on the orifice of the bladder, by which the urine cannot be evacuated. This not only occasions the usual painful sensations which accompany retention of urine, but very soon excites severe bearing-down pains, like those of labour. Partly from the effect produced on the lower part of the uterus by the distended bladder, but chiefly by the pressure of the superincumbent viscera, occasioned by the contraction of the abdominal muscles, the fundus is pressed lower, and the retroversion rendered more complete, and the bladder is still more closed up. The two prominent symptoms then of this complaint are, retention of urine, and bearing-down pains. These pains are more dependent on the state of the bladder than on the position of the uterus, for they are always worst when the bladder is fullest, or most irritated. Last of all, if the complaint be neglected, and the bladder continues unrelieved, inflammation takes place, and generally proves fatal. Our first and great object, therefore, ought to be, immediately to relieve the bladder, by introducing the catheter; and a regular recourse to this, keeping the bowels open, and allaying irritation, if necessary, by opiates, seldom fails in curing the patient. The best catheter to be employed is the gum one, and advantage may sometimes be derived from allowing it to remain in the bladder, so as to keep it constantly empty for some time. We have been urged to replace the uterus by pressure, but this often is not to be accomplished without much force, and in some cases, is almost impracticable. No instance has occurred to the writer where bad consequences followed from neglecting this attempt, and therefore he is still inclined to advise the more lenient though slower mode of trusting to the use of the catheter, rather than using force in endeavouring to replace the womb. At the same time, he has no objection, after the urine is drawn off, to make gentle pressure upwards on the fundus uterus, with the hand introduced into the vagina; but no strong efforts to elevate are advisable, nor, in any case, ought the attempt to be made, till the bladder be completely emptied.

CHAP. IV.

Of Abortion and Hemorrhage.

When the child is expelled so prematurely as to be unfit for living, the mother is said to suffer an abortion. This is always accompanied with separation of the ovum, and contraction of the womb itself. The first is production of discharge of blood, the second of pains analogous to those of labour. Sometimes the separation, and, in other cases, the contraction, is the first indication of abortion. If this event arise from any exertion, fright, or any other cause operating on the vessels, and occasioning detachment, the symptoms come on unexpectedly, and in general, the first is hemorrhage. If, however, it proceed from more latent causes, influencing the vitality of the fœtus itself, we usually observe certain precursory signs, which shew that the embryo or child is no longer alive. The morning sickness ceases, the breasts become flatter or fall off in size, the abdomen feels slack, and a sensation of heaviness is perceived in the lower part of it. If the patient be past the time of quickening, she now feels motion no more. Any one of these signs is not to be considered as evidence that abortion is inevitable, but when they are conjoined, there can be no doubt.

If the ovum be very inconsiderable in size, the symptoms attendant on abortion are chiefly those of uterine irritation, accompanied with hemorrhage, and differ little from those of painful menorrhagia. Nothing but coagula can be detected.

If the ovum be distinct, as in the second month, we have an attempt to contract, pains more or less regular, and greater disturbance of the abdominal viscera, and not unfrequently a tendency to syncope.

When the organization is more complete, and the ovum larger, as in the third month, we have still more distinct and regular pains, accompanied with hemorrhage and sympathetic symptoms. Sometimes the water is first discharged, then the fœtus, and last of all, the secundines; in other cases, the membranous bag comes away entire, enclosing the fœtus, and bringing along with it the fœtal posture of the placenta, and part of the decidua; the rest is afterwards thrown off.

When farther advanced, the process resembles still more nearly labour, except in being accompanied with greater discharge.

When the fœtus is expelled in abortion, it is usual for the discharge to mitigate, or stop for a time, then it returns, and sometimes with redoubled violence, previous to the expulsion of the secundines. These are thrown off, at different periods, from an hour to some days, but the general time is within 12 hours.

The duration of the whole process, as well as the nature and extent of the accompanying and sympathetic effects, vary much in different cases, and in some a portion, or the whole of the secundines, is so long retained as to become putrid, and produce bad consequences. In general, abortion is not attended with danger, if the constitution be not previously ruined, or the patient much sunk; but repeated miscarriages ultimately impair the health, and predispose to other diseases. Nor is the process itself altogether void of danger. Very lately, the author was consulted respecting a lady who had suffered a miscarriage in the second month, and who, when he saw her, was just expiring from hemorrhage, although she had been carefully and zealously attended by two intelligent gentlemen from the first.

A predisposition may be given to abortion by that imperfection which takes place in the uterus in advanced life. Repeated miscarriages also not only occasion a debility in the womb, but also, by the power of habit, give a tendency to injurious changes and actions about the same time in future pregnancies. General or local debility, produced in any way, has also a predisposing effect, and this is particularly the case when there is a relative plethora, or greater quantity of blood circulating in the vessels than their debilitated condition can sustain. An absolute plethora is another frequent predisposing cause, and is generally combined with an hemorrhagic disposition. Excessive irritability of the uterine system, or of the body altogether, renders abortion very apt to occur, and the same holds true of undue sympathy between the uterus and other organs. Some conditions of the ovum itself, too obscure to be detected, or which, either from the minuteness of the part, or destruction of organization which takes place, cannot be observed, must also be included. Delicacy of the membranes, excessive quantity of liquor amnii, diseased cord, or placenta, are amongst the number of causes. The exciting causes are numerous, and vary in different individuals. One of the most certain is, the death of the child, arising from affections or changes peculiar to itself, or from disorders and affections of the mother, such as sudden and severe cramp in the stomach or bowels. Passions of the mind have much influence on the uterus, disordering the circulation, and causing rupture of the connecting vessels, or exciting the muscular action of the womb. Violent sensations, as sudden immersion in cold water, or a large draught of cold drink, may cause abortion. Acrid medicine, or strong purgatives, or the irritation of piles, &c. are likewise exciting causes. Violent or sudden exertion, or any effort beyond the safe degree, will cause abortion; and in those who are predisposed to it, the most trifling exciting causes are sufficient.

Our object, in order to prevent abortion in those who are not yet threatened with it, is to counteract, as far as we can, the supposed predisposing causes, and avoid with care those which are existing. As a very frequent cause is plethora, with or without delicacy of the vessels of the ovum, a prominent part of attention is, the sanguiferous system. We lessen plethora by light diet, restriction in the quantity of liquids, laxatives, blood-letting, and moderate gentle exercise, if that be practicable, on account of the local condition. Diminution of the quantity of sleep, and avoiding heated rooms, and too warm beds, are also proper. When there is a strong predisposition, every thing which can excite the action of the uterus, or the activity of the vessels, must be shunned. Hence, in some cases, it may be necessary to confine the patient for some weeks, or even months, to a recumbent posture. It is needless to add, that all stimulants must be abstained from in such cases. When the cold bath agrees with the patient, it is useful, by rendering all the functions more perfect, and lessening the risk of plethora.

In debilitated habits, if the cold bath do not produce chilliness or disagreeable effects, it is of great utility. The diet ought to be neither so sparing as to continue, far less increase, weakness; nor, on the other hand, so full as to produce relative plethora.

Extreme irritability is lessened by laxatives, the shower bath, and, if combined with debility, by the use of light infusion of bark. If connected with plethora, as it often is, venesection is the best remedy. The repeated application of leeches to the neighbourhood of the vagina is a favourite remedy with some continental practitioners. In very nervous habits, when there is uneasiness in the uterine region, supposed to indicate the existence of spasm, the tepid bath, with antispasmodics, has been sometimes of service, and is certainly by no means dangerous.

When abortion is threatened, if we be not assured that the child is dead, we ought instantly to use means for stopping it. Blood-letting is a very general remedy, and a useful one, but it must not be carried too far; and the practitioner ought to regulate his conduct by scientific principles. There are chiefly two objects in employing the lancet; to lessen the activity of the circulation, and thereby diminish or check hemorrhage, and stop the farther separation of the ovum; and to abate irritability.

Spare diet, strict rest, cool air, tranquillity of mind. and the other means of lessening predisposition, must be rigidly enforced. The application of cold water to the back and perineum, by means of cloths, is often highly useful; and if the discharge be considerable, it ought to be commanded by stuffing the vagina. If there be any pain or general uneasiness, an opiate is useful; and, indeed, if there be no idiosyncrasy forbidding it, we ought in general to prescribe it. When there is a continued but moderate discharge, or repeated discharges, the use of a styptic injection is proper.

When we cannot prevent abortion from taking place, our next object is to conduct the process to a safe termination. The principal danger arises from the loss of blood, and therefore our chief attention ought to be paid to the prevention of this by stuffing, and the judicious use of cold. Faintness, feeling of sinking, or actual syncope, are removed by cool air, smelling hartshorn, opiates, and gentle cordials. The placenta ought, in general, to be left to come away by the uterine efforts; but, in the mean time, we must guard against hemorrhage by stuffing, or if the discharge be considerable, and the secundines can be brought away by the finger without irritation, that ought to be done.

When a portion of the placenta remains and putrefies, a febrile or hectic state is excited, the patient becomes sick, and the strength is much reduced both by fever and repeated hemorrhages, during the intervals of which fœtid matter is discharged from the vagina. The lower part of the belly is tumid, perhaps tender, and languor alternates with hysterical symptoms. If we can feel the portion, and easily extract it, this ought to be done; but we must not irritate. Injections of solutions of sulphate of alumine are proper, or of strong decoction of oak bark. The bowels are to be kept regular, the diet should be light aad nourishing; and the free use of fruit or vegetable acid, with the occasional exhibition of opiates, are proper. In prolonged cases, a gentle emetic may be of service in procuring the removal of the putrid mass.

It will be proper, in this place, to notice those hemorrhages which occur in the latter months of pregnancy, and which are attended with the greatest danger both to the mother and child. These have been divided into two classes; those arising from the implantation of the placenta over the os uteri, and those in which the placenta is attached higher up. This division is highly proper in one respect, but is neither safe nor useful, if it is to give rise to a rule of practice peculiar to each kind. The only safe rule is a general one, that no patient, in flooding, can be with impunity allowed to remain undelivered, after the state of the os uteri will permit of delivery.

The first attack of hemorrhage is in general sudden and severe, but it soon is suspended, or at least moderated. It often takes place during the night, and is usually unattended with pain. The effects produced by the first attack will depend on the strength and habit of the patient, and the severity of the hemorrhage. By a recurrence of the discharge, the strength however in every instance is greatly reduced, the patient becomes pale, and the pulse feeble. At the same time, slight but inefficient pains are excited. The os uteri becomes soft and dilatable, perhaps partially dilated, and hopes are entertained that labour shall come on and safely relieve the patient. Such hopes are never entertained by any man who understands the nature of the case, for although one or two patients may thus escape out of many hundreds, the rest die undelivered.

The plain and obvious practice to be followed is, to restrain the discharge by stuffing the vagina until the os uteri becomes dilatable, and then deliver the patient by turning the child. We thus do not interfere so early as to produce injurious irritation by harshly opening the os uteri, nor do we, on the other hand, permit the strength to be sunk to a hazardous degree. The concomitant treatment must proceed on general principles.

Part II. OF PARTURITION.

CHAP. I.

Of the Classification of Labours.

Labour may be defined to be the expulsive efforts made by the uterus for the birth of the child, after it has acquired such a degree of maturity as to give it a chance of living independently of its uterine appendages.

Labours may be divided into seven classes.

Class I. Natural labour; which may be defined to be labour taking place at the end of the ninth month of pregnancy; the child presenting the central portion of the sagittal suture, and the forehead being directed at first toward the sacro-iliac symphysis; a due proportion existing between the size of the head and the capacity of the pelvis; the pains being regular and effective; the process not continuing beyond 24 hours, seldom above 12, and very often not for six; no morbid affection supervening capable of preventing delivery, or endangering the life of the woman.

This comprehends only one order.

Class II. Premature labour; or labour taking place considerably before the completion of the usual period of utero-gestation, but yet not so early as necessarily to prevent the child from surviving.

This comprehends only one order.

Class III. Preternatural labours; or those in which the presentation or position of the child, is different from that which occurs in natural labour, or in which the uterus contains a plurality of children, or monsters.

This comprehends seven orders.

Order 1. Presentation of the breech.

Order 2. Presentation of the inferior extremities.

Order 3. Presentation of the superior extremities.

Order 4. Presentation of the back, belly, or sides of the child.

Order 5. Mal-position of the head.

Order 6 Presentation of the funis.

Order 7. Plurality of children, or monsters.

Class IV Tedious labour, or labour protracted beyond the usual duration; the delay not caused by the mal-position of the child, and the process capable of being finished safely, without the use of extracting instruments.

This comprehends two orders.

Order 1. Where the delay proceeds from some imperfection or irregularity of muscular action.

Order 2. Where it is dependent principally on some mechanical impediment.

Class V. Laborious or instrumental labour; labour which cannot be completed without the use of extracting instruments, or altering the próportion betwixt the size of the child and the capacity of the pelvis.

This comprehends two orders.

Order 1. The case admitting the use of such instruments as do not necessarily destroy the child.

Order 2. The obstacle to delivery being so great, as to require that the life of the child should be sacrificed for the safety of the mother.

Class VI. Impracticable labour; labour in which the child, even when reduced in size, cannot pass through the pelvis.

This comprehends only one order.

Class VII. Complicated labour; labour attended with some dangerous or troublesome accident or disease, connected in particular instances with the process of parturition.

This comprehends six orders.

Order 1. Labour complicated with uterine hemorrhage.

Order 2 Labour complicated with hemorrhage from other organs.

Order. 3. Labour complicated with syncope.

Order 4. Labour complicated with convulsions.

Order 5. Labour complicated with rupture of the uterus.

Order 6. Labour complicated with suppression of urine, or rupture of the bladder.*

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* The classification of labours is arbitrary, and varies according to the views of the writers and teachers of midwifery. Baudelocque, the most experienced of the French practitioners, and an able writer, has the following division:

1st. Labours which are accomplished by the efforts of nature alone.

2nd. Labours which require the assistance of art, but which may be completed by the aid of the hand alone.

CHAP. II.

Of Natural Labour.

The intention of labour is to expel the child and secundines. For this purpose, the first thing to be done by the process, is to dilate, to a sufficient degree, the os uteri, so that the child may pass through it. The next point to be gained is, the expulsion of the child itself, and last of all the fœtal appendages are to be thrown off. The process may therefore be divided into three stages. The first stage is generally the most tedious. It is attended with frequent but usually short pains, which are described as being sharp, and sometimes so severe as to be called cutting or grinding. They commonly begin in the back, and extend toward the pubis or top of the thighs; but there is in this respect a great diversity with different women, or the same woman at different times. Sometimes the pain is felt chiefly or entirely in the abdomen, the back being not at all affected during this stage; and it is generally observed, that such pains are not so effective as those which affect the back. Or the pain produced by the contraction of the womb may be felt in the uterine region; and when it goes off, may be succeeded by a distressing aching in the back. In these cases, the pain is confined to the small of the back and upper part of the sacrum, and is either of a dull aching kind, or sharp and acute, and, in some instances, is attended with a considerable degree of sickness, or tendency to syncope. The most regular manner of attack, is for pains to be at first confined to the back, descending lower by degrees, and extending round to the belly, pubis, or top and fore part of the thighs, and gradually stretching down the back part of the thighs, the fore part becoming easy: occasionally one thigh alone is affected. At this time, also, one of the legs is sometimes affected with cramp. The duration of each pain is variable. At first it is very short, not lasting above half a minute, perhaps not so long; but by degrees it remains longer, and become more severe. The aggravation, however, is not uniform; for sometimes, in the middle of the stage, the pains are shorter and more trifling than in the former part of it. During the intermission of the pains the woman is sometimes very drowsy, but at other times is particularly irritable and watchful. The pains are early attended with a desire to grasp or hold by the nearest object, and at the same time the cheeks become flushed, and the colour increases with the severity of the pain. The os uteri being considerably dilated, the second stage begins. The pains become different, they are felt lower down, they are more protracted, and attended with a sense of bearing down, or an involuntary desire to expel or strain with the muscles; and this desire is very often accompanied with a strong inclination to go to stool. A perspiration breaks out, and the pulse, which, during the first stage, beat rather more frequently that usual, becomes still quicker, the woman complains of being hot, and generally the mouth is parched. Soon after the commencement of this stage, it is usual for the liquor amnii to be discharged. This is often followed by a short respite from pain; but presently the efforts are redoubled. Sometimes there is no cessation, but the pains immediately become more severe, and sensibly effective. The perineum now begins to be pressed outward, and the labia are put upon the stretch. The protrusion of the perineum gradually increases, but it is not constant; for when the pain goes off, the head generally recedes a little, and the perineum is relaxed. Presently the head descends so low, that the parts are kept permanently on the stretch, and the anus is carried forward. Then the vertex pressing forward, the labia are elongated, and the orifice of the vagina dilated. The perineum is very thin, much stretched, and spread over the head of the child. As the head passes out, the perineum goes back over the forehead, becoming narrower, but still more distended laterally. If the perineum did not move backward as the head moved forward, it would run a greater risk of being torn; and indeed, even in the most regularly conducted labour, a part of it is often rent. Delivery of the head is accomplished with very severe suffering; but immediately afterwards the woman feels easy, and free from pain. In a very little time, however, the uterus again acts, and the rest of the child is expelled, which completes the second stage of labour. The expulsion of the body is generally accomplished very easily and quickly; but sometimes the woman suffers several strong and forcing pains before the shoulders are expelled. The birth of the child is succeeded, after a short calm, by a very slight degree of pain, which is consequent to that contraction which is necessary for the expulsion of the placenta. This expulsion is accompanied and preceded by a slight discharge of blood, which is continued, but in decreasing quantity, for a few days, under the name of the red lochia.

The existence and progress of labour, and the manner in which the child is placed, are ascertained by examination *per vaginam*.

Before labour begins, the os uteri is generally closed, and directed backwards towards the sacrum. When we examine, in the commencement of labour, the os uteri is to be sought for near the sacrum, at the back part of the pelvis, whilst between that spot and the pubis we can pass the finger along the fore part of the cervix uteri. On this the presenting part of the child

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3rd Labours which cannot be accomplished without the aid of instruments; or in which it is useful to employ them.

The classification adopted in the lectures on Midwifery in the University of Pennsylvania, is that of Smellie, improved by Hamilton and Denman, viz.

1st. Natural labour, where the head presents, and the child is expelled by the natural pains.

2nd. Difficult labour, where the head presents, but the birth is uncommonly protracted, or requires the interposition of art.

3rd. Preternatural labour, when any other part than the head first presents.

4th. Anomalous or complex labours, including those attended with hæmorrhage; with convulsions; when there is a plurality of children; or where the funis umbilicalis presents before the child—to which may be added, labours attended with rupture, or inversion of the uterus.

Each of the three first classes admit of divisions into *Orders*, which it is unnecessary to enumerate here.

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rests, so that in natural labour it assumes somewhat the shape of the head; and, for the sake of distinction, we shall call it the tumour.

In some, it is so firmly applied to the head, and so tense, that a superficaical observer would take it for the head itself. In this case the labour often is lingering. This tumour, or portion of the uterus, is broad in the beginning of labour, but becomes narrower as the os uteri dilates, until at last it is completely effaced, the head either naked, or covered by the membranes occupying the vagina. The breadth of this portion of the uterus, therefore, as well as the examination of the os uteri, will serve to ascertain the state of the labour. The protrusion of the membranes, and discharge of the liquor amnii, ought to bear a certain relation to the advancement of labour. Whilst the os uteri is beginning to dilate, the membranes have little tension; they scarcely protrude through the os uteri, until it be considerably opened. But in proportion as the dilatation advances, and the pains become of the pressing kind, the membranes are rendered more tense, protruding during a pain, and becoming slack and receding when it goes off. In the first stage of labour, the head will be found placed obliquely along the upper part of the pelvis, with the vertex directed toward one of the acetabula. The finger can easily ascertain the sagittal, and afterwards the lamboidal suture; the central portion of the sagittal suture is the point from which we set out, and, if the finger be readily led to the angle formed by the posterior edges of the parietal bones, we may be sure that the presentation is favourable. If, on the other hand, we can feel the anterior fontanelle, the vertex is generally directed to the sacro-iliac articulation. When the pelvis is well formed, and the cranium of due size, the head may commonly be felt in every stage of labour; but there are cases in which, even although the pelvis be ample, it is not easily touched for some time.

When the vertex comes to present at the orifice of the vagina, or passes a line drawn from the under edge of the symphysis pubis back to the sacrum, the perineum and skin near the tuberosities of the ischia become full, as if swelled, but not tense. This at first proceeds from relaxation of the muscles, and some degree of descent of the vagina and rectum. Whenever this is felt, we may be sure that the head is descending; but although a few pains may distend the perineum, it may yet be some hours before this takes place, the pains for all that time appearing to produce very little effect, although the pelvis be well formed. Should the perineum become stretched, and the anus be carried forward a little during the pain, we may expect that delivery is at hand. If the patient have already born children, the child is sometimes delivered within a few minutes after the perineum is first felt to become full.

It is immaterial in what posture the patient place herself during the first stage of labour; but in the second stage, when delivery is approaching, it is proper that she be placed on her side, and it is usual for her to lie on her left side, as this enables the practitioner to use his right hand. The knees are a little drawn up, and generally at this time kept separate by means of a small pillow placed between them. Many women wish to have their feet supported, or pressed against by an assistant, and it is customary to give her a towel to grasp in her hand. This is either held by the nurse, or fastened to the bed-post. We must however be careful that these contrivances do not encourage the woman to make too strong efforts to bear down. When the patient is in bed, it is proper to have a soft warm cloth applied to the external parts, in order to absorb any mucus or water that may be discharged—and this is to be removed when it is wet. Attempts to dilate the os uteri or the vagina in natural labour, and the application of unctuous substances to lubricate the parts, are now very properly abandoned by well-instructed practitioners. The membranes ought generally to be allowed to burst by the efforts of the uterus alone, for this is the regular course of nature, and a premature evacuation of the water either disorders the process and retards the labour, or, if it accelerate the labour, it renders it more painful. We cannot, however, go the length of some, who say, that the artificial evacuation of the water is always hurtful; for there are circumstances in which it may be allowable and beneficial.

Examination ought, in the first stage of labour, to be practised seldom; but, in the second stage, we must have recourse to it more frequently; and when the pains are becoming stronger, and the head advancing, we must not leave the bedside.

As the fæces are generally passed at this time involuntarily, a soft cloth is to be laid on the perineum; and when the second stage of labour is drawing to a conclusion, the hand is to be placed on this, in order to prevent the rapid delivery of the head, and the consequent laceration of the perineum. This is a point of very great importance, and which requires to be carefully considered by the practitioner.

The last advice to be given respecting this stage of labour is, that as we retard rather than encourage the expulsion of the head, so we are not to accelerate the delivery of the body.

The child being born, a ligature is to be applied on the cord very near the navel, and another about two inches nearer the placenta. It is then to be divided betwixt them, and the child removed. The hand is next to be placed on the belly, to ascertain that there be not a second child, and the finger may, for the same purpose, be slid gently along the cord to the os uteri. The hand of an assistant should be applied on the abdomen, and gently pressed on the uterus, which may excite it to action, and prevent torpor. If the placenta be not expelled soon, the uterine region may be rubbed with the hand, to excite the contraction of the womb. Immediately after the expulsion of the child there is often a copious evacuation of water, which is sometimes mistaken by the woman for a discharge of blood. But hemorrhage never takes place so instantaneously, in such quantity. It is generally a minute or two, sometimes much longer, before flooding comes on. Against the occurrence of this, we are to be on our guard.

Soon after the birth of the child, the placenta is expelled, and this process is accompanied by a trifling discharge of blood and a little pain. However, it sometimes happens that it is retained, and the retention may or may not be complicated with flooding. If it be, all are agreed on the propriety of introducing the hand first to excite the uterus, and then to extract the placenta. But if their be no flooding, many, from a fanciful conceit of the powers of nature, are for doing nothing. It is warrantable and proper to extract it entirely at the end of an hour, if it be still retained.

In every instance, but more particularly of tedious labour, and in those cases where there has been the smallest indication of irregular or spasmodic action of the womb, it is indispensable that we repeatedly ascertain that no hemorrhage has taken place; and this ought not to be neglected, even after the placenta has been naturally expelled. Whether the placenta be retained or thrown off, the treatment is the same, namely, to excite the regular contraction of the uterine fibres. This is without loss of time to be done, by introducing the hand into the uterus, when, in almost every instance, it will be found that a circular or spasmodic contraction has taken place. This is to be gently dilated with the hand, which is to be moved constantly or pressed lightly against the interior surface, so as to excite universal action; nor is it to be withdrawn till that be accomplished. If the placenta be still retained, it is to be carefully brought down through the contraction into the inferior part of the womb, when it may be left so long as the spasm remains. Pressing on the abdomen, particularly over the uterus, and gently grasping of the womb, through the abdominal position, tends to excite action, whilst the exhibition of a full dose of laudanum contributes to allay the spasm. The strength is in the mean time to be supported by stimulants; and when the attack has been severe, by the sedulous use of light nourishment. We must not, however, carry the cordial plan too far, as there is in such cases a propensity to inflammation of the womb afterwards.

CHAP. III.

Of Premature Labour.

When labour is established, it is to be conducted much in the same way with parturition at the full time; but the following observations will not be improper. The patient must avoid much motion, lest hemorrhage be excited. Frequent examination and every irritation are hurtful, by retarding the process, and tending to produce spasmodic contraction. If this contraction take place, marked by paroxyms of pain, referred to the belly or pubis, little or no effect being produced on the os uteri, a full dose of tincture of opium should be given, after the administration of a clyster. Severe pains, with premature efforts to bear down and a rigid state of the os uteri, require venesection, and afterwards an opiate. The delivery of the child is to be retarded rather than accelerated in the last stage, that the uterus may contract on the placenta. This is farther assisted by rubbing gently the uterine region after delivery. If the placenta be long retained, or hemorrhage come on, the hand is to be gently introduced into the uterus, and pressed on the placenta to excite the fibres to throw it off. We should not rashly attempt to remove it, for we are apt to tear it; neither are we to pull the cord, for it is easily broken. In those cases where premature labour is connected with redundance of liquor amnii, it is useful to introduce the hand immediately on the delivery of the child, for the placenta is apt to be retained by irregular contraction. We do not instantly extract the placenta, but it is desirable to get the hand in contact with it before the circular fibres contract. Great attention is to be paid to the patient for some days after delivery, as she is liable to a febrile affection, which may be either of the inflammatory type, or of the nature of weed, to be afterwards noticed.

CHAP. IV.

Of Preternatural Labour.

Order First.

The breech is distinguished by its size and fleshy feel, by the tuberocity of the ischia, the shape of the ilium, the sulcus between the thighs, the parts of generation, and by the discharge of meconium, which very often takes place in the progress of labour. After the breech has descended some way into the pelvis, the integuments may become tense or swelled, so as to make it resemble the head. Before the membranes burst, the presentation is usually very mobile, and bounds up readily from the finger, but in some instances it is from the first firmly pressed down in the pelvis, and felt through the uterus very much resembling the head.

Many have advised, that when the breech presented, the feet should be brought down first; but the established practice now is, when the pelvis is well formed, and other circumstances require speedy delivery, to allow the breech to be expelled without any interference, until it has passed the external parts.

Order Second.

Presentation of the feet is known, by there being no rounded tumour formed by the lower part of the uterus. The membranes also protrude in a more elongated form than when the head or breech present. The presenting part, when touched during the remission of the pain, is found to be small, and affords no resistance to the finger. When the membranes break, we may discover the shape of the toes and heel, and the articulation at the ankle. Sometimes both the feet and the breech present. Two circumstances contribute to an easy delivery; *first*, That the toes be turned to the sacro-iliac junction of the mother; and *secondly*, That both feet come down together. The best practice is, to avoid rupturing the membranes till the os uteri be sufficiently dilated; then we grasp both feet and bring them into the vagina; or, if both present together at the os uteri, we may allow them to come down unassisted.

Order Third.

When the shoulder or arm presents, the case has the general character of preternatural presentations. The round tumour, formed by the head in natural labour, is absent, whilst we can ascertain the shape and connection of the arm and shoulder. A shoulder presentation can only be confounded with that of the breech. But, in the former case, the shape of the scapula, the ribs, the sharpness of the shoulder-joint, and the direction of the humerus, together with our often feeling in our examination either the hand or neck, will be distinguishing marks. In the latter, the rounder shape and greater firmness of the ischium, the size of the thigh, its direction upwards, and its lying in contact with the soft belly, the spine of the ilium, the parts of generation, the size of the tuberosity of the ischium, and the general shape of the back parts of the pelvis, contribute with certainty to ascertain the nature of the case.

In most cases where the superior extremities present, the feet of the child are found in the fore part of the uterus, toward the navel of the mother. But their situation may be known by examining the presentation.

We should be careful not to rupture the membranes prematurely; and more effectually to preserve them entire, we must prevent exertion, or much motion on the part of the mother. As soon as the os uteri is soft, and easily dilatable, the hand should be introduced slowly into the vagina, the os uteri gently dilated, and the membranes ruptured. The hand is then immediately to be carried into the uterus, and upwards till the feet are found. Both feet are to be grasped betwixt our fingers, and brought down into the vagina, taking care that the toes are turned to the back of the mother. The remaining steps have been already described.

But if the water have been long evacuated, then the fibres of the uterus contract strongly on the child, the presentation is forced firmly down, and the whole body is compressed so much, that the circulation in the cord is frequently impeded, and, if the labour be protracted, the child may be killed. This is a very troublesome case, and requires great caution. If the pains be frequent, and the contraction strong, then all attempts to introduce the hand, and turn the child, must not only produce great agony, but, if obstinately persisted in, may tear the uterus from the vagina, or lacerate its cervix or body. Copious blood-letting certainly has a power in many cases of rendering turning easy. If the patient be restless and feverish, or the part rigid, it is to a certain extent necessary and proper, and ought to precede an opiate; but if these states do not exist, we shall generally succeed, by at once giving a powerful dose of tincture of opium, not less than sixty or eighty drops. Previous to this, the bladder is to be emptied, lest it should be ruptured during the operation; and, if necessary, a clyster is to be administered. The patient is then to be left, if possible, at rest. Sometimes in half an hour, but almost always within two hours after the anodyne has been taken, the pains become so far suspended, as to render the operation safe, and perhaps easy.

In some instances, when no attempt was made to turn the child, the uterus has burst, and the patient died, whilst, in others, nature has at length effected the expulsion with safety to the mother.

A knowledge of the fact that the child may be thus evolved does not exonerate us from making attempts to turn; for although a considerable number of cases are recorded where it has taken place, yet these are few in proportion to the number of presentations of the shoulder; and in a large city containing above 100,000 inhabitants, the author has only learned of one instance where this has taken place.

Order Fourth.

The hips, back, belly, breast, or sides, may, though very rarely, present, the child lying more or less transversely. The hip is sometimes taken for the head, but is to be distinguished by the shape and relations of the ilium. In all the other cases, the presentation remains long high; but when the finger can reach it, the precise part may be ascertained, by one who is accustomed to feel the body of a child. In these presentations the hand should be introduced, to find the feet, by which the child is to be delivered. This rule is absolute with regard to all those presentations, except that of the hip, which only renders labour tedious, and in this the practice must be determined by concomitant circumstances.

Order Fifth.

The child may present the head, and yet it may be improperly situated, and give rise to painful and tedious labour.

1st, The forehead, instead of the vertex, may be turned towards the acetabulum. In this case, the presentation is felt in the first stage high up, smooth, and flatter than usual. In a little longer, we discover the anterior fontanelle, and the situation of the sutures. By degrees, the head enters the cavity of the pelvis, the vertex being turned into the hollow of the sacrum, and by a continuance of the pains, the forehead either turns up within the pubis, and the vertex passes out over the perineum, or the face gradually descends, and the chin clears the arch of the pubis, the vertex turning up within the perineum towards the sacrum, till the face is born. The first is the usual process in this presentation; all the steps of the labour are tedious, and often, for a considerable period, the pains seem to produce no effect whatever. In the last stage, the perineum is considerably distended, and it requires care and patience to prevent laceration. If it be discovered early, it is certainly proper to rupture the membranes, and turn the vertex round; a proceeding which is easily accompl shed, and which prevents much pain and fretfulness. If this opportunity be lost, we may still give assistance. The late Dr. Clarke says, that in thirteen out of fourteen cases, he succeeded in turning round the vertex, by introducing either one or two fingers between the side of the head near the coronal suture and the symphysis of the pubis, and pressing steadily, during a pain, against the parietal bone.* The writer of this article fully concurs in the opinion given by that excellent practitioner. The fontanelle, or crown of the head, may also present, although the face be turned to the sacro-iliac junction. In this case it is felt early, and, by tracing the coronal suture, we may ascertain whether the frontal bones lie before or behind. It is a much more uncommon presentation than that noticed above. The labour is, at first, a little slower than in a natural presentation, but, by degrees, the head becomes more oblique, the vertex descending; and this may be assisted, by supporting the forehead with the finger during a pain.

2d, The side of the head may present. In this case the presentation is long of being felt, but it is recognised by the ear. If, however, it has been long pressed in the pelvis, it is extremely difficult to determine the case. It is very rare, and has even been deemed to be impossible. In some instances the child has been

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* This mode of proceeding appears to have been first recommended by Baudelocque. J.

turned, but it is most common to rectify the position of the head, by introducing the hand.

3*d*, The occiput may present, the triangular part of the bone being felt at the os uteri. It is known by its shape, by the lamboidal suture, and its vicinity to the neck. The forehead rests on some part of one of the psoæ-muscles, and from this oblique position of the head, the labour is tedious. It has been proposed, in this case, to turn; but it is better, if we do any thing, to rectify the position of the head with the hand. Nature is, however, adequate to the delivery, even if not assisted.

4*th*, The face may present, with the chin to one of the acetabula, or to the sacro-iliac junction, or to the pubis or sacrum. The first two are the best, the third is more troublesome, and the last is worst of all.

If the presentation be discovered early, there can be little doubt as to the propriety of rectifying the position, but, if the labour be advanced, this is difficult; and then it only remains that we should endeavour, if the labour be severe and tedious, to make the face descend obliquely, by cautiously, but firmly supporting with a finger, during the pains, the chin or end which is highest, in order to favour the descent of the lower end. When the chin has advanced so far as to come near the arch of the pubis, we may follow a different method, and gently depress it, which assists the delivery, for generally the chin is first evolved.

Order Sixth.

Sometimes the cord descends before, or along with the presenting part of the child. This has no influence on the process of delivery, but it may have a fatal effect on the child. As soon as the os uteri will admit the introduction of the hand, the child should be turned, if it can be easily done. But if the presentation be advanced before we are called, and turning be difficult, then we must endeavour to keep the cord slack, or remove it to that part of the pelvis where it is least liable to be compressed: or it will be still better to endeavour, with two fingers, to push the cord slowly past the head, and prevent it, for two or three pains, from coming down again.*

Should this not be practicable, and the pulsation suffer, or the circulation be endangered, we must accelerate labour by the forceps.

Order Seventh.

The signs by which the existence of a plurality of children are said to be indicated, are so completely fallacious, that no reliance can be placed upon them, nor can we generally determine the existence of twins, until the first child be born. Then, by placing the hand on the abdomen, the uterus is felt large, if it contain another child, and by examination *per vaginam*, the second set of membranes, or some part of the child, is found to present. This mode of inquiry is proper after every delivery.

If the first child present the head, the second generally presents the breech or feet, and *vice versa;* but sometimes the first presents the arm, and, in that case, when we turn, we must be careful that the feet of the same child be brought down. This first being delivered, the hand is to be again introduced, to search for the feet of the second child, which are to be brought into the vagina, but the delivery is not to be hurried.

It sometimes happens that, after the first child is born, the pains become suspended, and the second is not born for several hours. Now this is an unpleasant state, both for the patient and practitioner. She must discover that there is something unusual about her; he must be conscious that hemorrhage, or some other dangerous symptom, may supervene. The first rule to be observed is, that the accoucheur is on no account to leave his patient till she be delivered. The second regards the time for delivering. Some have advised that the case be entirely left to the efforts of nature, whilst others recommend a speedy delivery. The safest practice, if the head present, lies between the two opinions. If effective pains do not come on in an hour, the child ought to be delivered by turning.

It remains to be observed, that we ought to be peculiarly careful in conducting the expulsion of the placentæ of twins. Owing to the distention of the uterus, and its continued action in expelling two children, there is a greater than usual risk of uterine hemorrhage taking place. The patient must be kept very quiet and cool; gentle pressure should be made with the hand externally on the womb, and no forcible attempts are to be permitted for the extraction of the placentæ, by pulling the cords. If hemorrhage come on, then the hand is to be introduced to excite the uterine action, and the two placentæ are to be extracted together. The application of the bandage, and other subsequent arrangements, must be conducted with caution, lest hemorrhage be excited.

CHAP. V.

Of Tedious Labour.

Order First.

Tedious labour may occur under three different circumstances:

First, The pains may be from the beginning weak or few, and the labour may be long of becoming brisk.

Second, The pains during the first stage may be sharp and frequent, but not effective; in consequence of which the power of the uterus is worn out before the head of the child have fully entered into the pelvis, or come into a situation to be expelled.

Third, The pains during the whole course may be strong and brisk, but, from some mechanical obstacle, delivery may be long prevented, and it may even be necessary to have recourse to artificial force.

Different causes may produce tedious labour, which cannot be minutely enumerated in this place. Amongst these we may mention a slight disproportion between the capacity of the pelvis and the size of the head of the child, rigidity of the soft parts, unnatural strength of the membranes, &c. One of the most frequent is, inefficient action of the uterus, during which the pains, though productive, perhaps, of considerable sensation, have little efficacy, or they may be deficient both in point of sensation and effect. Various causes may pro-

* In these cases it is recommended to raise the hips of the patient considerably above the level of the head, and keep them in that situation until the cord may have receded, and the presenting part of the child taken its place. J.

duce this; as for instance, premature evacuation of the liquor amnii, undue distention of the womb, torpor of the uterine fibres, passions of the mind, &c. and it is a fact, that the same exciting causes may, in different cases, produce very different, and even opposite effects, in consequence of concomitant circumstances. In general, it is not necesssary to interfere artificially, unless the labour be unusually tedious, or complicated with some urgent symptoms. Stimulants are neither safe nor allowable, if we except the exhibition of a clyster, to excite the uterus sympathetically. An opposite plan is more useful, namely, instead of endeavouring to increase the force, to diminish the resistance, which is most readily done by venesection. Hippocrates was well acquainted with the good effect of detracting blood in facilitating labour. He advised it to be taken from the foot, but the modus operandi is the same, whatever vein be opened, and it is deeply to be regretted, that the opinion of this great man was so long neglected. Blood-letting is safe in every case, where a debilitated constitution, or exhausted system, or previous fatigue, do not forbid it. In many cases, more particularly when the os uteri is rigid, or the soft parts do not relax, it is productive of most speedy improvement. The diminution of resistance, and augmentation of expulsive force, do not bear an exact proportion to each other, but the latter is in a high ratio to the former, and when the expulsive action is once much excited, it goes on increasing. This principle is illustrated by the fact, that parturition is greatly accelerated by rupturing the membranes, and thereby allowing the water to run out, and the uterus to contract; a practice which ought not to be adopted unnecessarily, but which, in tedious labour, is often attended with most marked benefit. A change of posture also is useful, so as to make the power of gravity correspond with the uterine efforts. Hence, standing or kneeling is often of benefit; an erect position is also of service, by the stimulus given to the sensible os uteri by the greater pressure of the presentation. Walking gives an additional excitement to the action. Another advice to be given is highly important, namely, that when the pains are regular, but not effective, and the labour proves to be tedious, the os uteri should be gently dilated, so as to be completely opened within from ten to fourteen hours from the establishment of labour. The exact time cannot be laid down to suit any case, as a little latitude within these periods must be allowed, according to the state of the pains and the condition of the patient, and the effect already produced on the os uteri. It is not meant to say that the rule is absolute; for pains may, after continuing a few hours, go off for a day, and the os uteri may scarcely be affected. In such cases, interference is improper. But if the pains have regularly continued, and the os uteri have yielded slowly, and to an imperfect extent, and the presentation is felt resting on it, a delay beyond 12 hours will generally be productive of future exhaustion of the uterus. This is a principle which has most ably been explained by Dr. Hamilton, who has insisted on the great danger of allowing the first stage of labour to be unduly protracted. By pressing steadily but gently on the anterior margin of the os uteri during a pain, with two fingers resting on the head, it is safely and easily dilated to its full extent, by persisting for several pains in succession, or repeating our gentle endeavour at longer intervals. This, especially if preceded by blood-letting, never fails to dilate completely the os uteri; and those natural efforts of the womb, which would have otherwise been requisite to open the mouth of the womb, are spared, and the strength and force directed to the expulsion of the child. The pains generally become stronger and bearing down, not so much from the gentle stimulus applied to the os uteri, as on the principle already laid down. All resistance is taken away from the lower part of the uterine cavity, and the muscular action has only to force the head through the pelvis. Even when the necessity of instrumental aid is anticipated, this practice ought to be adopted; and indeed in such cases, above all others, is important. When the os uteri is rigid or tumid, blood-letting ought never to be omitted, unless the patient be debilitated, and at once render it dilatable and soft. In this desirable state of the mouth of the womb, if its aperture be equal to half-a-crown, the membranes may be ruptured with advantage, if they have not already given way; and the principle on which this advice is given has been explained above. On the other hand, when the os uteri is rigid, the membranes ought to be preserved entire until relaxation take place. Opening them is also improper, if the os uteri be very irritable. The writer is well aware that these directions may be misrepresented, and, perhaps, by some ignorant people misunderstood, and supposed to encourage rashness and irritation, and improper interference with natural labour. He is little accustomed to conceal his sentiments, from the wish to screen responsibility, and believing that these opinions are of great importance in the management of tedious labour, he deems it a duty to support and recommend them. When the pains are deficient from debility, excited by previous fatigue, it is generally proper to procure a suspension by an opiate, more especially if the water have been discharged. In a state of fatigue, when we wish to procure rest, or when the os uteri remains rigid, and in a debilitated patient, where we dare not use the lancet with safety, a full dose ought to be given, and it is most safely administered as a clyster. On the other hand, when our object is to excite the pains rather than to suspend them, a small dose, 20 or 25 drops for instance, may be given, and often has the effect of rendering the action brisker.* It is useful previously to learn, if we can, how the medicine agrees with the patient. The strength is to be supported by light and mild nourishment, and sometimes a little wine.

Irregular action of the uterine fibres is another cause of tedious labour, and which, amongst other sources, very often arises from the spontaneous discharge of the liquor amnii before, or in the commencement of labour. The pains produce little effect, and when they go off, leave behind them a distressing uneasiness in the back. A saline clyster, and pressing up the head of the child gently during a pain, to procure the more perfect evacuation of the liquor amnii, are useful. Blood-letting is proper, if the os uteri be rigid or tumid, which is often the case, especially if the waters have been prematurely discharged. If these means fail, or have not been proper, as for instance in consequence of previous debility, an ano-

* For the purpose of exciting more energetic contractions of the uterus in the cases alluded to above, nothing has been found so effectual as the ergot of rye, by some called Secale Cornutum, in doses of 15 or 20 grains, but not repeated frequently. J.

dyne clyster, or opium suppository, is of benefit. If this state should exist, without evacuation of the water, it is useful, if the os uteri be soft, thin, and considerably dilated, to rupture the membranes. In all these cases, the advice already given, not to allow the os uteri to remain too long undilated, ought to be acted on. After a time the child is expelled, but spasmodic contraction and hemorrhage are apt to follow. When labour is rendered tedious, by the accession of fever, or local inflammation, the lancet and cool air, with a laxative clyster, are the most useful means of relief, whilst timely recourse should be had to the forceps, if necessary.

Order Second.

When there exists a disproportion between the size of the child and the capacity of the pelvis, labour must be more or less tedious and severe. In such cases, our attention ought to be directed to the regulation of the bowels, evacuation of the urine, the preservation of strength, particularly by avoiding all unnecessary exertion, the procuring of sleep, and a respite from suffering, if that can be safely done by an opiate, and, above all, to the prevention of dangerous exhaustion, by not permitting the first stage of labour, or the complete dilatation of the os uteri to be too long protracted, and afterwards having timely recourse to artificial delivery.

CHAP. VI.

Of Instrumental Labour.

Order First.

When the head of the child, and the cavity of the pelvis, do not bear a just proportion to each other, the resistance to the passage of the head may be so great as to prevent the safe delivery of the child. The increased obstacle either for a time checks the full expulsive action of the womb, and ultimately unfits it for accomplishing its purpose, or affords such resistance as not to be safely overcome by the most severe efforts which are ultimately excited. It is, however, a great error to suppose, that this is the only case requiring the aid of instruments; for the resistance afforded by the soft parts, and various other causes influencing the action of the uterus, and producing tedious labour, may render them necessary. Many females require the forceps for the delivery of their first child, who afterwards are naturally delivered both with facility and celerity. These two cases have been noticed by practical writers under the distinction of impaction and arrest, the first being supposed, and justly, to require more prompt interference than the second. It is, however, much to be feared, that in both there is an undue backwardness to interfere, and an overweaning confidence placed in the powers of nature. It is indeed true, that, in many of these cases, the child may be at last expelled without artificial aid; but in no small proportion of instances there is good ground to fear that it shall be still-born, and that the mother shall sink from hemorrhage or exhaustion, or have fatal inflammation excited. The danger in protracted labour is greater to the child than the mother; that is, the one perishes sooner than the other. From the tables of Dr. Breen, exhibiting the result of the practice in the Dublin lying-in hospital, it appears that, out of 196 women who had tedious labour of their first child, but were delivered by the efforts of nature, 59 bore dead children; that is, three-tenths of the children were lost. If we come to particulars, we find, that when the labour lasted from 30 to 40 hours, rather more than one-fifth of the children was lost, and 1 woman in 34 died. When it lasted from 40 to 50 hours, three-tenths of the children were lost, and one woman in 13. When it continued from 50 to 60 hours, 1 woman in 11 died, and not quite one-third of the children were still-born. It is impossible to form a comparison of these results with those where instruments were employed, because they were always delayed long, or, when employed early, were resorted to under dangerous circumstances. In little more than half a century, 780,001 women were delivered in the Dublin hospital, and at an average 1 child in 18 was still-born. The deaths among women were as 1 to 92. It is impossible to draw all the important conclusions here which might be done from these documents; but the following facts cannot fail to strike the reader. In women who were between 30 and 40 hours in labour of their first child, and delivered without aid, 1 woman in 34, instead of 92, the average of the whole, died; and 1 child in 5, instead of 18. If the woman have previously borne children, protracted labour becomes more dangerous, as it must generally have arisen from the state of the pelvis; for in the same period 1 woman in 11 died; but the loss of children was rather less, namely, 1 in 6. In the range of the next 10 hours, that is to say, if more than 40, and under 50, were allowed to elapse, 1 woman in 13, and 3 children out of 10, were lost. The conclusion is against delay. It is quite a mistake to suppose, that the application of the forceps by a careful practitioner is necessarily more painful or more dangerous than the efforts made by nature for the expulsion of the child in such cases. On the contrary, the sufferings of the mother are both shortened and diminished, and her subsequent safety ensured, whilst the life of the child is preserved, which otherwise would be lost. Doubtless the unnecessary and wanton use of instruments is strongly to be reprehended; but much and pretty long experience has convinced the writer of this article, that of the two extremes of premature and dilatory recourse to the forceps, the latter is by far the most dangerous, and the most to be dreaded. He is particularly happy to embrace the present opportunity of expressing his concurrence in the sentiments maintained on this subject by Dr. Hamilton, the justly celebrated professor who fills the obstetric chair in Edinburgh, and to whom the profession is indebted for many advantages, and for none more than his powerful recommendation of early recourse to instrumental aid.

To deliver precise rules for the time and manner of applying the forceps, which ought decidedly to be preferred to the lever, would require a more minute detail than is compatible with this work, nor is it perhaps necessary, as these are fully laid down in those elementary books which are in the hands of every practitioner. The following observations, however, may be useful:

1*st*, In every instance, where there is reason to apprehend a tedious or difficult labour, it is of importance to prevent the first stage from being unnecessarily protracted. When the pains are regular, but productive of little effect, the means already pointed out for procuring dilatation of the os uteri within a limited period, generally twelve hours, ought to be employed.

2*d*, If the delivery can be accomplished by the forceps, it is possible to apply the instrument whenever the os uteri is completely dilated, but not sooner.

3*d*, Although the last assertion be true, yet it is generally found that the more the head has advanced in the pelvis, the easier is the application of the instrument, with the exception of those cases where the head is firmly wedged in the pelvis In such cases it has been necessary to raise it up a little. When the ear of the child can be felt behind the pubis, when a considerable part of the cranium corresponds to the hollow of the sacrum, and the perineum is touched, or a little pressed by the head, the case may be managed with the forceps, without much difficulty.

4*th*, A rule has been laid down, that before we apply the instrument, we should allow the head to rest on the perineum for six hours; that is, that we shall delay to act for six hours after action has become easy. There is no rule more absurd, and less to be depended on, for we may sometimes delay much longer; and in other cases, be required to deliver much sooner.

5*th*, We never ought to allow the head to remain long impacted, that is, much pressure to continue for a length of time on the soft parts, nor ought we to permit the uterine action to become exhausted, far less the general strength to be much impaired. If we do, uterine hemorrhage succeeds delivery, or inflammation comes on after it, or the uterus is ruptured; and, in the case of impaction, if the patient escape this risk, she is liable to sloughing of the soft parts, particularly of the urinary organs. Continued pressure produces swelling of the soft parts in the pelvis, which impedes delivery. It is preceded by heat and dryness of the vagina, which indicate inflammation coming on, and, if delivery be not resorted to, the case is likely to prove fatal.

6*th*, Whenever we find that the head is remaining stationary for several hours, and the uterine efforts doing no good, although frequent and painful, and when the ordinary means advised in tedious labour prove of no avail, we are warranted to interfere. A prolongation of suffering would only endanger both mother and child. It is no reasonable objection to this, that we find women continue in severe labour for some days, and yet not only bear the child without aid, but recover well. The fact is undoubted; but, on the other hand, it is no less certain that a great many such cases end fatally. It is quite impossible to say where the limits of safety end, or to lay down a general rule with respect to time. Regard must be paid to the strength and constitution of the patient, her age, to the circumstance of her being in labour for the first time, the fatigue endured, the effect of the pains, and the inefficacy of other means. Let us ascertain what the powers of nature can do so long as we safely may wait, and neither interfere rashly, nor delay dangerously. The combination of other evils or accidents adds to the urgency of the case.

7*th*. When it is quite ascertained that the pelvis is considerably contracted, we ought to deliver as soon as the head comes into a favourable place. The patient, in all probability, shall have had labour sufficiently severe, before the head have entered so far into the pelvis, and permitting labour to continue longer, is only adding unprofitably to her sufferings.

8*th*, If the pelvis be contracted, and especially if this state be combined with spasmodic action of the uterus, the head may be very long of entering the pelvis, or may never descend so low as is supposed in the third remark. In such a case, it becomes necessary to determine whether the forceps can be applied, or the child must be destroyed, by opening the head, and using the hook or extracting pincers. In the middle of the last century, long forceps was used by Dr. Smellie and others, when the head was high. On the Continent, the late excellent practitioner, Baudelocque, was, and the present energetic Dr. Osiander is, successful in this mode of using the forceps, which also has been advised by Dr. Hamilton, who, like Smellie, uses both a long and a short pair. In doubtful cases, an attempt certainly ought to be made to save the child; but repeated and irritating efforts are to be discouraged; nor, in any case, are they admissible, when the conjugate diameter is determined to be only three inches. The writer has seen persevering efforts made with the best intention, but ending at last in the use of the crotchet, and in the accession of inflammation, even before the delivery of the child.

9*th*, The blades of the forceps are to be successively introduced along the opposite sides of the head, sliding gently, and with the utmost tenderness. They are to be accurately and cautiously joined, and having ascertained that the application has been properly effected, and the fixture is secure, extraction during a pain, or at intervals, if the pains have gone off, is to be made in the direction of the axis of that part of the pelvis through which the head is passing. In doing this, time is to be considered as better than force.

Order Second.

The necessity for mutilating or destroying the child, can only arise from a mechanical cause, and almost uniformly from great contraction of the pelvis. When this is occasioned by tumours, these may frequently be extirpated; but when it proceeds from an alteration in the figure of the bones, the perforator ought to be employed as soon as it is ascertained that a living child cannot pass, and afterwards, if necessary, the crotchet is to be applied. Where great deformity is known to exist sufficiently early, the practice of inducing premature labour ought in preference to be adopted. A living child, at the full time, cannot pass, if the conjugate diameter of the pelvis be only three inches.

CHAP VII.

Of Impracticable Labour.

Some have rashly asserted, that in every case delivery might be accomplished by breaking down the child, but it is more sober minded to place very little reliance on this opinion. There can only be two modes of effecting the delivery of a child, the first through the pelvis, the second, by making an incision into the uterus, in those cases where the first mode is impracticable. This, which is known under the name of the Cesarean operation, is one of much simplicity, and very easly performed, but one of the utmost danger, not to the child, but to the mother. This danger arises from two sources, exhaustion produced by irritation or injury, consequent to the exposure of the abdominal cavity; and peritoneal inflammation, which is the most frequent of the two. There is at present only one instance where the mother has survived in Britain, but many successful cases have occurred on the continent, in consequence of the operation being there performed earlier, and under more favourable circumstances. In the latest case which is published, Dr. Locker, at Zurich, saved both mother and child. In Britain, the delivery of the woman would have been performed with the crotchet, as the life of the child is never put in competition with that of the mother, which is so greatly hazarded by the Cesarean operation.

CHAP. VIII.

Of Complicated Labour.

Order first.

When labour is complicated with uterine hemorrhage, no time ought to be lost in delivering the child, if the discharge be considerable. This is to be effected, either by turning or by using the forceps, according to the stage. No reliance can be placed in any serious case on the practice of rupturing the membranes.

Order Second.

When hemorrhage takes place from the vessels of the stomach or bowels, but particularly of the lungs, it is evident that a prolongation of labour cannot fail to be dangerous. Delivery ought to be accelerated, and indeed can seldom be trusted to the natural efforts. The lancet and other ordinary means of cure must also be resorted to.

Order Third.

If the paroxysm be repeated or severe, we must deliver, and employ cordials. It is also indispensable that the abdomen be properly compressed after the expulsion of the child.

Order Fourth.

The most frequent kind of puerperal convulsions is the epileptic, if we retain the nosological definition of Cullen, who includes under epilepsia the eclampsia or acute clonic spasm of Sauvages, one species of which is the *eclampsia parturientium.* They are generally preceded by headach and other symptoms of determination to the head, and are usually very severe and frequently repeated. Indeed, in many cases, they recur with the regularity of labour pains. Sometimes there is only one paroxysm, and the patient, without any interference whatever, goes on safely, but this result can never be depended on, and it is to be feared that the more probable termination would be fatal apoplexy, or a destruction of the vital principle during the severe convulsions which are excited. Two causes contribute materially to the production of this disease; the first is an undue determination of blood to the head, either by predisposition or by a peculiar state of the nervous system, excited by the condition of the uterus. The second is a costive and loaded state of the bowels, which operates powerfully on the brain. From this view it is easy to see, not only in what the prophylaxis, but also the treatment should consist. The lancet is to be powerfully and freely employed, the bowels are to be opened by a smart clyster, and if these means, particularly the former, carried as far as prudence dictates, do not put a stop to the disease, delivery must be artificially accomplished.

Order Fifth.

Rupture of the uterus, during labour, may undoubtedly take place suddenly and unexpectedly, but in most instances it is owing to mismanagement, particularly to delaying too long the use of the forceps, or allowing the child to remain in an unfavourable position without rectifying it, or to violent and injudicious attempts to turn the child when the uterus is acting strongly. The child usually escapes through the laceration into the cavity of the belly, the labour pains cease, great restlessness and sickness, vomiting, with rapid diminution of strength succeed, and generally within a few hours the sufferer is carried off. Peritoneal inflammation often comes on most rapidly, but it is possible for death to be caused by mere exhaustion, and sinking from abdominal irritation.

The best practice, generally speaking, is to introduce the hand through the laceration, and bring away the child by the natural passage.

Order Sixth.

The danger arising from suppression of urine is too obvious to require any reasoning to enforce the necessity of attention to this point in every case of tedious labour. When the catheter cannot be introduced, or relief obtained by cautiously raising up the head of the child, this complication calls for the cautious application of the forceps, at a period earlier perhaps than we would otherwise be led from the state of the pains and other circumstances to recommend.

Part III. OF THE PUERPERAL STATE.

CHAP. I.

Of the Management immediately after Delivery.

When the after-birth is expelled, it is too much the practice with many to sit up in bed immediately, and have the clothes shifted. Most alarming floodings, and other bad consequences, may result from this. The first thing to be done is, very slowly to remove the wet sheet from below the patient, she next turns slowly on her back, and has a bandage applied so firmly round the belly as to give the feeling of a pleasant support. The bandage often consists of a broad towel folded double, but it is better to have one made of stout cotton cloth, with tapes to tie, or buttons, with two rows of holes. It is prevented from slipping upwards and wrinkling by a thigh-piece, and in some cases it may be necessary also to have a shoulder strap. Many, with advantage, apply under this a compress, made of a napkin or quilted pad. The bandage being applied, a flannel petticoat, open in the middle, is next put on, and wrapt round the limbs, and a soft napkin is to be applied to absorb the discharge. If the patient be fatigued, no more is to be done, but if she be not, an aired shift and bedgown can be put on, and she is laid to rest; but if a half shift be used during labour, there is seldom great occasion to change it, for several hours at least. Although we are thus cautious respecting speedy shifting on account of the effect often produced by slight exertion, especially after a lingering labour, or in delicate women, yet the necessity of changing the clothes, as soon as prudence will permit, ought to be inculcated, and afterwards shifting every day, and having the discharge washed away, morning and evening, with a sponge and lukewarm water. The number of bed-clothes must be regulated by the season, but they never should be so many as to promote sweating, which weakens the patient, and gives a tendency to catch cold. It is usual to give some cordial after delivery, such as brandy or cinnamon-water. Unless the strength be exhausted, there is seldom occasion for this, and it often does harm. A little wine and water may be given if fatigued, or a little panado with wine; or if the labour have been lingering, and there is much langour, a little Madeira wine, without water, is very proper.

A stool should be procured within thirty-six hours after delivery, by means of a suitable dose of magnesia, or a little castor oil. If the patient is not to nurse, the laxatives should be rather brisker.

The urine should always be passed within twelve hours, at farthest, after delivery, and if there be any difficulty in voiding it, fomentations will be useful. After a severe labour, it is necessary to be very attentive to the voiding of the urine, and the state of the soft parts.

The diet ought to be light, and should consist, for the first two days, of tea and cold toast for breakfast, beef or chicken soup for dinner, and panado for supper. Afterwards a bit of chicken may be taken for dinner, and, as recovery goes on, the usual diet may be returned to. In these directions, however, regard must be had to the previous habits and present state of the patient.* The drink at first should be toast water, and malt liquor is, for some days, to be avoided; wine, or wine and water, may then be allowed, if no fever be present, and the weakness or former habits of the patient require it. In a good recovery, the patient may have the bed made on the third day, but, during the time, she should recline on a sofa. In a day or two longer she may be allowed to be dressed and sit a little, but ought not to walk about or leave the room for some time; and, even in summer, should not go out for an airing in less than three weeks. Many, before this time, do rise, and even attend to domestic cares earlier, but they often suffer very much, either from a weakening discharge, or a falling down of the womb.

CHAP. II.

Of Tremor and Fainting Fits.

It is not unusual for women, very soon after delivery, to be seized with a violent shaking or shivering, sometimes in consequence of rash and sudden exposure to cold, after being heated with the exertion of labour, but often from no evident cause. Nothing, in general, gives so speedy relief as a pretty large dose of laudanum, forty drops, for instance, in peppermint water, or in a little brandy and water. At the same time, the patient is kept in perfect rest, and when she is inclined to shake, she must be held gently by an assistant, so as to prevent her from doing so in a great degree. If she feel cold, and the teeth chatter, the application of a warm cloth to the stomach and feet is useful. This is not a dangerous, and seldom an obstinate, affection. If it, however, should be prolonged, camphor is of service.

Fainting is always an alarming symptom, and when it occurs, the first thing to be ascertained is, whether there be a great discharge or flooding, in which case the danger is extreme, and the treatment of this has been already pointed out. It may also attend inversion of the womb. But some women are, after a tedious and severe labour, and others even after very little suffering, liable to a short and temporary exhaustion, approaching to a fainting fit, or very often to that kind of insensibility or lowness, which occurs in a hysteric attack, and like it, this is frequently preceded by an involuntary crying or sobbing, immediately after the birth of the child. This hysterical lowness is not dangerous; indeed, there is never great ground for alarm, whilst the pulse continues, and there is no discharge, for in this case the patient may rather be said to be in a state of stillness and quietness than fainting. In those cases where this state occurs after delivery, a few drops of oil of cinnamon on sugar are useful, or we give thirty drops of laudanum in a little brandy, or hartshorn and water, whilst a free circulation of air is to be preserved. Volatile tincture of valerian is recommended by Dr. Hamilton to be given, as soon as the child is born, to those who are subject to fainting fits, and certainly is a useful remedy.

Actual syncope is much more alarming, even when it does not proceed from hemorrhage, great fatigue, or any other evident cause. There have been instances of sudden death following an easy labour, and in which no sufficient cause could be ascertained by dissection. The ordinary means of exciting the nervous and vascular system must be resorted to, and persevered in.

CHAP. III.

Of After Pains.

After pains are sometimes extremely troublesome during the first three days after delivery, and may even be more distressing than those of labour. They proceed from different causes, but the most frequent is the contraction of the womb to acquire its original size, and expel clots. This often occasions irregular grinding pains in the lower part of the belly, and sometimes in the back, like those of labour. They are usually accompanied with the discharge of clots of blood, and frequently are renewed for a day or two, whenever the child is applied to the breast. They are most effectually relieved by a full dose of laudanum, and warm fomentations. Gentle laxatives, and uniform pressure externally, contribute to relief. Another kind is accompanied with wind in the bowels. The pain is not merely felt in the bottom of the belly, but in different parts, and comes on often like gripes or cholic pains,

* As in many women there is a considerable disposition to fever and increased arterial action, animal food and wine or malt liquor, should be avoided, until the secretion of milk is fully established, and all symptoms of fever have disappeared. J.

sometimes accompanied with a little fulness of the belly, and pain on pressing hard. This is relieved by a clyster to open the bowels, afterwards a dose of laudanum in peppermint water, and fomentations. An injection, containing laudanum, is also useful. Sometimes worms cause this pain. Severe pains between the ribs and haunch hone may attack in paroxysms, continuing for more than half an hour, and then going off completely. These may be accompanied with quickness of pulse, and the urine is high coloured. They are relieved by opiates, fomentations, sinapisms, and laxatives; and sometimes a pretty firm bandage gives temporary relief. Constant pain, accompanied with shivering, vomiting, swelling, and tenderness of the belly, fever, and suppression of the cleansings, indicate inflammation, and require the earliest attention.

CHAP. IV.

Of Displacements of the Uterus.

Pain in the back and lower part of the belly, with a strong beating down, weakness, feeble pulse, and discharge of blood, require examination, lest the womb be inverted. If much time be lost, the inversion may either prove quickly fatal, or remain during the whole of life.

If the uterus be inverted, examination detects a fleshy tumour filling the vagina, whereas, if the womb be properly situated, the vagina is free, and the os uteri is felt open and empty. When the inversion is complete, the uterus is protruded altogether, and forms a fleshy mass, which projects externally. In either case, it must be immediately reduced by moderate pressure, and in general this is easily accomplished. When it has been neglected and becomes chronic, extirpation has in different instances been practised, on account of the injurious effect produced by the repeated hemorrhages, mucous discharges, and continued irritation attendant on this state. Some of these have succeeded perfectly; and in one the author saw the patient in perfect health many years after the operation.

It must next be observed, that in consequence of weakness and relaxation, or of rising and walking too soon, the womb, being yet heavy and large, may sink too much in the vagina, or may even come to protrude externally. This, in the first degree, is called a bearing down of the womb, and where it proceeds so far as to appear outwardly a procidentia uteri; but this extreme degree fortunately seldom happens at first. The patient for a length of time complains of weakness, and pain in the back, a sense of dragging about the loins, weariness and aching about the thighs and lower part of the belly, and unpleasant sensations when she attempts to walk, particularly a bearing down; and by and bye, when the womb descends lower, she cannot make water easily, and in the whole progress of the complaint the stomach and bowels are apt to be disordered, both in their functions and sensations. These affections of the bowels and stomach are very often prominent symptoms, leading off the attention of the patient from the true cause, which sometimes can only be discovered by the examination of a skilful practitioner.

This is a complaint which generally proceeds from relaxation, or from some exertion before the womb has returned to its usual size, or from its remaining for a length of time larger than usual. This naturally suggests a caution against rising too soon, or making any early exertion; and it is peculiarly incumbent on those who are delicate in constitution, or enfeebled by previous disease, to be on their guard in this respect. Although, doubtless, rash management on the part of the midwife may occasion this complaint, yet it is much oftener the fault of the patient herself. It must also be impressed on the mind, that it may succeed a miscarriage, or may even occur in unmarried women, from excessive discharge, fluor albus, or violent exertion, when out of order. Rest in a recumbent posture is of the greatest service in the early stage. The bowels are to be kept in a very regular state, by daily doses of Cheltenham salt, or sal polychrest, or any other mild laxative, in order to lessen the quantity of circulating fluid; and for the same purpose liquids ought to be avoided, that the uterus may speedily diminish in size and weight. The diet should be such as tends to increase the strength, and for the same purpose, in a month after delivery, the cold bath may be employed, if no particular symptom forbid it. The application of a proper bandage round the whole belly, with a moderate degree of firmness, often gives great relief to the uneasy feelings; and the early use of a compress over the uterine region, so as to excite to absorption, may be useful. Astringent injections tend to contract the vagina, and are sometimes of benefit. If these means fail, then we must employ a pessary. This is a complaint which is apt to be increased during the first three months of subsequent pregnancy, but after the third month it disappears.

There is another affection which may be confounded with this, namely, a relaxation and protrusion of the vagina itself. This forms a soft swelling or prominence at the orifice of the vagina, which sometimes completely encircles the opening, but oftener is more on the one side than on the other, or is greatest behind. It gives no particular inconvenience, unless it exist in a great degree, and it usually disappears on going to bed. It requires the use of astringent decoctions, or alum water, externally, or employed as injections, and the frequent application of cold water, by means of a sponge. Internal astringents, such as tincture of kino, have been thought useful. If the patient be weak, strengthening remedies are proper, such as bark, steel, the cold bath, &c. In this, as well as in the former complaint, it is of great service to support the perineum permanently; the best mode of doing which, is by an elastic steel truss similar to that used for prolapsus ani.

CHAP. V.

Of Irregularities of the Lochial Discharge.

An increased, and sometimes a continued discharge, after delivery, is often the consequence of getting up too soon, or making some early exertion. It is usually attended with pain in the back, and always produces weakness. It is to be removed by avoiding exertion, taking some strengthening medicine, such as bark and wine, and using, if it continue, the shower-bath. The aching pain in the back is often removed by the applition of an adhesive or warm plaster.

The lochial discharge is in some women very trifling, and may even stop very soon without any bad effect. But when it is suddenly checked by exposure to cold, or other causes, most painful consequences may follow, such as swelling of the belly, great pain, sickness, and fever. These symptoms are dangerous at all times, but are still more to be dreaded, as they often attend inflammation, and indeed the two cases can only be distinguished by minute attention. A purgative clyster should be instantly administered, a cloth, soaked in oil of turpentine, or hot fomentations applied to the belly, and a perspiration encouraged by a saline julep, containing antimonial wine, together with tepid drinks. An anodyne clyster is also useful, and if the pain continue, the lancet must be used. In this disease, the suppression of the discharge is an effect rather than a cause, and indeed does not uniformly take place, for the symptoms arise from spasm of the uterine fibres. This differs from inflammation in coming on most suddenly; the pain from the first is severe, but it remits, or sometimes for a few seconds goes entirely off. But it must not be supposed that this state can continue long without exciting inflammation.

Ill-smelled discharge proceeds from clots of blood lodging about the womb, and requires strict attention to cleanliness; it may even be necessary to wash the discharge from the passage, by means of a syringe. If, however, this discharge be attended with sickness or nausea, quick pulse, hot skin, parched hands and feet, thirst and want of appetite, or repeated discharges of blood, and pain in the lower part of the belly and back, then there is reason to conclude that part of the after-birth remains in the womb, and great attention is necessary to preserve the patient. This affection often passes at first for a weed.

The patient is worn out by nocturnal perspiration, fever, and want of nourishment, until at length a putrid mass is discharged from the womb, perhaps about the ninth or tenth day, or even after some weeks of suffering, and then the patient generally recovers.

The bowels are to be regulated, either by laxatives or opiate injections, according to their state. The diet must be light, such as chicken broth, beef tea, calf's-feet jelly, arrow root, &c. The elixir of vitriol is useful for promoting appetite and checking perspiration. Camphorated mixture is of service for allaying nervous affections. Great attention must be paid to cleanliness and ventilation. Astringent injections have been employed, and sometimes with advantage.

CHAP. VI.

Of Swelled Leg.

After delivery, one of the legs is sometimes affected with a painful swelling, which is often, though not always correctly, attributed to some violence in the labour, or some imprudence afterwards. It makes its appearance about ten days after delivery, sometimes sooner or even later. It begins with fever, and pain in the back, or lower part of the belly, particularly about the groin, where there is considerable stiffness felt. The pain may gradually extend down the limb, but more frequently it is, after these symptoms, suddenly felt in the calf of the leg or knee, and presently the whole limb, which formerly perhaps was cold, becomes hot and swelled. The acute pain slowly abates, but the limb continues tender, and can scarcely be moved. The pulse becomes much quicker, the face pale, the strength is greatly impaired, and frequently very copious perspiration adds to the weakness.

The duration of this disease is variable, but in general it is considerable, and occasionally after one thigh becomes better, the other becomes affected with similar symptoms. In one case, which lately was attended by the author, the inferior and both superior extremities were successively attacked. The complaint in the upper parts was preceded by pain and stiffness in the side of the chest. There is always great debility attendant on this disease, and even a tendency to syncope.

The treatment consists in the immediate application of leeches, or of hot solution of acetite of lead to the groin, at the same time that a purgative is administered. If the symptoms go on, and the limb becomes affected and swelled, relief is sometimes obtained by rubbing with camphorated oil, or tincture of soap and opium;* but fomentations with hot water are more generally useful. At the same time the bowels are to be kept regular with cream of tartar, and sleep procured by anodynes.† When the acute symptoms are over, and the limb only remains weak, friction with the flesh-brush is proper, and a roller should be applied with moderate firmness from the toes to the groin. The cold bath is useful to re-establish the health. The diet ought, after the inflammatory symptoms have abated, to be nourishing, and the re-establishment of the health is promoted by removing to the country. Tonic medicines at this period are also useful.

CHAP. VII.

Of Ephemeral and Remittent Fevers.

Women, who are disturbed much in their repose, who have suffered greatly during labour, who have very sore nipples, who are inattentive to their diet, distressed in their mind, or exposed to cold, are liable to an attack of fever, called in this country a weed. The fit begins with chillness, cold feet, and violent trembling; pain in the back, headach, and in some instances, inclination to vomit. Presently flushes of heat are felt, which at last become steady, and the patient feels extremely hot and restless. In some time afterwards, perspiration breaks out, continues for a considerable time, and at last abates, leaving the patient free from fever, but very languid. During both the cold and hot stage, the pulse is frequent, and there is thirst; but in the sweating stage both these symptoms decline. The whole fit is usually finished within twenty-four hours, frequently in a much shorter period. There may be only one attack, but it is not

* The unguentum stramonii has sometimes been used advantageously.

† In some cases the disease has only yielded to the use of mercury, carried so far as to touch the mouth. J.

uncommon for the fits to come on every day for more than a week, nearly about the same time, or an hour sooner or later each day; and in that case they are preceded by coldness in the back, accompanied with aching pain. In this state the stomach becomes filled with wind, the bowels are bound, and the patient is timid or hysterical. In some instances there is a state of complete apyrexia, in others only a remission of the symptoms. Short attacks of this fever are not in general dangerous; but if they be repeated and prolonged, it is probable that they depend on, or are kept up, by some local disease. There may be incipient and obscure disease in some of the great cavities of the body, or the mammæ may be partially affected. In all such cases it is therefore necessary to examine minutely into the symptoms and sensations, for it has happened that some patients have been suddenly cut off, who were supposed to be in little danger.

When the cold fit comes on, our object is to hasten the hot one, which is done, not by putting many bedclothes on the patient, for these are hurtful, but by giving frequently a small quantity of some warm drink, such as gruel or lemonade, and applying a bottle, filled with warm water, to the feet and pit of the stomach, or to the back, if it feel cold. When the hot fit is established, these applications are to be removed, and the tepid drinks continued till the sweat comes out. Means are not to be employed for pushing this far, but by taking a very little drink, and lying quiet for some hours, it is to be encouraged to continue in a moderate degree, till all the uneasy feelings and feverish symptoms are removed. Then warm dry linen is to be put on, and cold avoided with care. It requires much prudence to say when the perspiration ought to be checked, but it is a good general rule, to continue it till the fever is removed. After the sweating is over, a little panado with wine is proper. A repetition of the fever is to be prevented, by avoiding those causes which first brought it on, keeping the bowels open, taking some strengthening medicines, such as bark, and procuring rest by opiates. When there is a tendency to return, and no local disease can be detected, the fit is sometimes checked by taking twenty-five drops of laudanum an hour before the expected time of attack, and applying warm flannel to the back. During the intervals, infusion of bark, or the cautious use of arsenic, will be useful.

If palpitation occur frequently, either along with this fever or without it, the best remedy is a large dose of laudanum, in a glass of peppermint water, and during the interval, the volatile tincture of valerian, with laxatives, or the camphorated mixture, will be proper.

If the attacks of fever be repeated, or if it become continued, it will be necessary to give up nursing; and indeed in many cases the secretion of milk becomes so much diminished as to render it impossible for the child to be nourished by the parent. When local pain, or symptoms indicating the existence of inflammatory action in any organ appear, no cure can be expected till that organ be relieved.

CHAP. VIII.

Of Milk Fever.

The secretion of the milk is often accompanied with a considerable degree of fever, called the milk fever. This is partly owing to that disturbance which is always to a certain degree excited in the system, whenever a new process is established, and partly owing to the swelling or irritation of the breasts themselves. In this view, it may, though of short duration, be compared to the teething fever of infants. This fever commences about the second or third day after delivery, and consists of a cold, a hot, and a sweating stage, during each of which, the symptoms are so much the same with those described under the name of weed, or ephemeral fever, that it is needless to repeat them. It must not, however, be supposed, that the fever takes place in every instance, more than that every child has a teething fever: and even in those cases where the fever is considerable, there is very little danger. There can be no difficulty in distinguishing this disease, for the breasts are full, hard, and painful, circumstances which at once point out the nature of the complaint. By way of preventing this fever, it has been recommended, that the child be applied to the breast as soon after delivery as the strength of the patient will permit, and this is extremely proper if the trial be made in such a way as not to fatigue her. It is also useful to procure a stool early, and it is even proper, where the patient is stout, of a full habit, and does not purpose to nurse, to give laxatives more freely, in order to diminish the quantity of milk, and prevent swelling and irritation of the breasts.

When milk fever does take place, the treatment is very simple, consisting in giving warm drink, such as gruel, or lemonade, in small quantity during the cold stage, and applying warm flannel to the feet and stomach. In the hot stage, the curtains are to be thrown open, the coverlet taken off, and tepid drink, with gentle diaphoretics, given to excite perspiration. In the sweating stage, the perspiration, which is generally sour-smelled, is to be gently encouraged, till it be universal, and the patient feel relieved, then it is to be lessened, and the management is the same as in weed. These means are to be employed to an extent, and with a degree of attention, proportioned entirely to the severity of the symptoms.

CHAP. IX.

Of Inflammation of the Breasts.

When, in consequence of exposure to cold, or of the pain and tension, occasioned by the retention of the milk, in those who do not, or cannot suckle, inflammation of the breast is excited, there is great reason to apprehend that suppuration will take place. This disease is easily known by the pain, hardness, and swelling which accompany it. In some cases, the whole breast seems to be affected, in others, only one half, and in many the affection is more circumscribed, or small and superficial. This complaint is generally accompanied by fever, and that is sometimes smart, when the mammary affection is so obscure as to escape observation for several hours, or even for a day or two. When the breast inflames, it is evident that the retention of the milk must, for a time at least, increase the pain. The first and earliest object, therefore, must be to have the breast gently drawn, either by the child or by other means, provided these attempts do not give pain, for if they do so, and the milk do not come readily, more hurt than good will be done. The breast should be gently fomented with a sponge dipped in tepid water, and then covered with a poultice of bread and milk, so as to continue the soothing effects of the fomentation. The patient should keep in bed, and have the breast properly supported. Spare dry diet and laxatives are proper. If the pain and hardness do not very soon go off, but, on the contrary, the former becomes more severe and throbbing, suppuration must take place, and it is to be encouraged by bread and milk poultices, applied hotter than formerly. If the abscess be small and superficial, the spot soon becomes red, and at last breaks, occasioning, comparatively speaking, little distress, and scarcely giving any interruption to nursing. But if it be deeper, or more extensive, and the glandular part of the breast be affected, all the symptoms are more severe, the progress is tedious, and the strength is apt to be reduced by fever, perspiration, and want of appetite. In these cases, if the abscess do not point and break soon, no good can be gained by delay, an opening should be made so as to evacuate the matter freely. This not only gives immediate relief, but prevents a farther extension of the mischief, and the foundation of future disease. In every instance, a free opening should be procured for the pus, and if sinuses form, these must be opened completely and at once. In unhealthy inflammation of the breast, different glands may successively be affected in both breasts, and slow abscesses form, which produce troublesome sinuses when they burst. In all such cases, it is necessary daily to examine the breast, for the constitution is apt to be undermined by repeated attacks of shivering and fits of fever. The stomach is impaired, anorexia and reaching take place, and a fatal cachectic state is produced. These shiverings are removed by opening the abscess, or evacuating the confined matter, and the general health is restored, by laying open any sinuses which may form. Light nourishment, with a liberal proportion of wine, varied tonics, and the use of opiates and laxatives, according to circumstances, are proper. Indurations or local affections from torpidity are benefited by a gentle course of mercury. When the patient can take nourishment, there is seldom any great danger; but if she have a perpetual and intractable loathing at food, with diarrhœa, and especially if she be of a strumous habit, there is much ground to fear ultimately a fatal issue. In some instances the mesenteric glands, in others the uterus itself, are affected in the course of the disease, which may be protracted for some months.

CHAP. X.

Of Uterine Inflammation.

Inflammation of the womb usually begins between the second and fifth day after delivery, but it may take place at a later period. It is pointed out by a pain in the lower part of the belly, which gradually increases in violence, and continues without intermission, though it is subject to occasional aggravations. The uterine region is very painful when it is pressed, and it is a little swelled. There is, however, no general swelling of the abdomen with tension, unless the peritoneum have become affected. But the parietes are rather slack, and we can feel the uterus distinctly through them to be harder than usual, and it is very sensible. There is also pain felt in the back, which shoots to the groins; and there is usually a difficulty of voiding the urine, or a complete suppression, or distressing degree of strangury. The situation of the pain will vary according to the part of the uterus first and principally affected. The internal parts become also frequently of a deep red colour, and the vagina and uterus have their temperature increased. The lochial discharge is very early suppressed, and the secretion of milk diminished or destroyed. Nearly about the same time that the local symptoms appear, or perhaps a little earlier, the system becomes affected. The pulse very early becomes frequent, and somewhat hard. The patient is chilly, or has a shivering fit succeeded by increased temperature of the skin, and it is not unusual for her to be sick, or to vomit bilious fluid. The tongue is white and dry, and the urine high coloured and turbid. The vomiting in some cases continues, and the bowels are at first bound, but afterwards the stools are passed more frequently. If the peritoneum come to partake extensively of the disease, then we have early swelling and tenderness of the abdomen, and the danger is greatly increased.

This disease calls for the early and free use of the lancet, which is the principal remedy; and the number of times that we repeat the evacuation, must depend upon the constitution of the patient, the effects produced, and the period of the disease. If three or four days have passed over, the pulse may be full and frequent; but this is an indication that suppuration is going on, which will be ascertained by throbbing pain, &c. In this case the lancet is hurtful. Mild laxatives are also highly proper. Fomentations are very useful, and external irritations are likewise of benefit after the acute stage has been subdued by the lancet. The application of oil of turpentine is perhaps as useful as any other that can be made. Diaphoretics ought to be administered, such as the saline julep, with the addition of antimonial wine and laudanum. This is the best internal remedy we can employ. Emollient clysters, or sometimes anodyne clysters, give relief. In the suppurative stage we must keep the bowels regular, give light nourishment, apply fomentations, and allay pain with anodynes. When the matter is discharged, a removal to the country will be useful, and tonic medicines should be given.

CHAP. XI.

Of Peritoneal Inflammation.

The peritoneal lining of the abdomen, or the covering of the intestines, may be inflamed alone; or this disease may be combined with inflammation of the uterus.

Peritoneal inflammation may be caused by violence during delivery, or the application of cold, or the injudicious use of stimulants. It may not come on for three weeks after delivery, but it usually commences on the second day, and earlier than inflammation of the womb; and it may often be observed, that the pulse continues frequent from the time of delivery. It is preceded or attended by a shivering and sickness, or vomiting, and it is marked by pain in the belly, which sometimes is very universal, though, in other cases, it is at first confined to one spot. The abdomen very soon becomes swelled and tense, and this state rapidly increases. The pulse is frequent, small, and sharp, the skin hot, the tongue either clean, or white and dry; the patient thirsty, she vomits frequently, the milk is not secreted, and lochia are frequently obstructed. These symptoms often come on very acutely, but it ought to be deeply impressed on the mind of the reader, that they may also approach insidiously. Wandering pain is felt in the belly, neither acute nor altogether constant. It passes for after-pains, but it is attended with frequency of pulse, and some fulness of the belly, and a little sickness. But whether the early symptoms come on rapidly or slowly, they soon increase, the belly becomes as large as before delivery, and is often so tender, that the weight of the bed-clothes can scarcely be endured; the patient also feels much pain when she turns. The respiration becomes very difficult, and sometimes a cough comes on, which aggravates the distress, or it exists from the first, attended with pain in the side as a prominent symptom. Sometimes the patient has constant belching, and brings up mouthfuls of fluid, which always gives pain. The bowels are either costive, or she purges bilious or dark-coloured fæces. These symptoms are more or less acute, according to the extent to which the peritoneum is affected. They are at first milder and more protracted in those cases where the inflammation begins in the uterus; and in such the pain is often not very great nor very extensive for some time. If the disease is to prove fatal, the swelling and tension of the belly increase, so that the abdomen becomes round and prominent, the vomiting continues, the pulse becomes excessively frequent and irregular, the fauces are apthous, death is marked in the countenance, the extremities cold, and the pain usually ceases rather suddenly. The patient has unrefreshing slumber, and sometimes delirium mite, but she may also remain sensible to the last. The disease usually proves fatal within five days, but may be protracted for eight or ten days, or even longer.

The practice in this disease is very limited, but very important. It consists in an instant recourse to the lancet, which is to be used at first with freedom, but in more advanced stages with circumspection. If it is to prove useful, it will do so soon; and a frequent repetition toward the latter end can only hasten death. Whilst, therefore, the writer places his chief reliance on this remedy, he cautions against its abuse.

Fomentations are soothing and useful, and all the pained part of the abdomen ought to be covered with a cloth wet with oil of turpentine.

The bowels are to be opened by laxative medicine, and stimulants of any kind are to be avoided. Fruits and grateful drinks are to be prescribed.

CHAP. XII.

Of Puerperal Fever.

Puerperal fever begins sometimes in an insidious manner, without that shivering which usually gives intimation of the approach of a serious malady. In other cases, the shivering is perceived, and varies considerably in degree, being either slight or pretty severe. The first symptoms, independent of the shivering, are frequency of pulse, oppression, nausea, or vomiting, pain in the head, particularly above the eyebrows. The night is passed with little sleep, much confusion, and occasionally some delirium; but this is not common in the commencement.

It must not, however, be forgotten, that in many instances there is no headach in any stage of the disease, nor any sickness nor vomiting in the beginning. In some, the temper from the first is uncommonly iritable, in others there is much timidity, or listlessness, or apathy. Hysterical symptoms not unfrequently supervene.

From the beginning, or very soon afterwards, pain is felt in the belly; at first slight, but it soon increases, and in some instances the abdomen becomes so tender, that even the weight of the bed clothes is productive of distress. A general fulness, without tension of the belly, accompanies this from the first, and it usually increases pretty rapidly, and may proceed so far as to make the patient nearly as large as she was before delivery. In such cases the abdomen becomes tense, and the breathing is much oppressed; indeed, in every instance, the respiration is more or less affected; the free action of the abdominal muscles, which are concerned in that function, being productive of pain. The degree of pain, its seat, and period of accession, vary in different cases. In some it evidently begins in the uterus, and, coming in paroxysms, resembles severe after-pains, but never goes entirely off, and is accompanied with bearing-down. The uterine region is painful, particularly toward one side. The os uteri, if examined, is not much more sensible than usual. There is generally pain in the back. In other cases the pain is first felt about the lower part of the ribs on one side, and is accompanied with cough. The belly is tumid, and tender when pressed, but except then, or in turning, the patient complains little of it. Sometimes severe pain, like spasm, attacks the iliac region, and extends down to the thigh, and toward the pubis and bladder.

The face is sometimes flushed at first, or a patch of deep red appears on the cheeks, but the countenance in general is altogether pale, or at least not suffused, the eyes are without animation, and the lips and angles of the eyes are white. The whole features indicate anxiety and great debility. When vomiting occurs at the very commencement, it is generally bilious. In the course of the disease, it becomes so frequent that nothing will stay in the stomach; and, towards the conclusion of the fever, the fluid thrown up is dark-coloured like coffee, and frequently fœtid. This is a symptom which always, if it do not proceed from a morbid structure, indicates, in whatever disease it occurs, an entire loss of tone of that organ, and in this fever is a fatal symptom. But, to proceed with the history. There is, in many instances, great dejection of mind, and always langour, with general debility of the muscular fibres, and the patient lies chiefly on her back, or there is so much listlessness, that she sometimes makes little complaint. The skin is not very hot, but is rather clammy and relaxed. There are cases, however, where the patient complains of universal and oppressive heat, until toward the end, when the extremities become cold. In other instances the temperature varies, the patient being alternately hotter and cooler. The tongue is pale or white at first, but presently becomes brown, and uniformly apthæ appear in the throat, and extend down the œsophagus, and over all the inside of the mouth. From the irritability of the stomach and bowels, it is highly probable that these organs participate in the tender state, and the upper part of the larynx seems to be affected from the cough which is excited.

It has already been mentioned, that the pulse, from the first, is very frequent, and at that period it is fuller than in simpler peritoneal inflammation, but it soon becomes feeble. The thirst is not always great, at least the patient is often careless about drink. The bowels are often at first bound; but afterwards, especially about the third day, they usually become loose, and the stools are dark, fœtid, and often frothy. This evacuation seems to give relief. The urine is dark-coloured, has a brown sediment, and is passed frequently, and with pain. The lochial discharge continues for a time, but presently is diminished, has a bad smell. or is changed in appearance, or gradually ceases; and it is observable that the re-appearance of the lochia, if they had been suppressed, is not critical. The secretion of milk stops, and the patient inquires very seldom about the child. In bad cases, the swelling of the belly increases rapidly, but the pain does not always keep pace with the swelling, being sometimes least when the swelling is greatest, and in the end it generally goes entirely off. The breathing becomes laborious in proportion as the belly enlarges. The strength sinks, the pulse, always frequent, becomes weak and tremulous, the throat and mouth appear sloughy; perhaps the stools are passed involuntarily, and the patient usually dies about the fifth day of the disease, but in some cases not until the fourteenth, in others, so early as the second day. In some instances death is preceded by low delirium, or stupor; in others the mind continues unimpaired till within a few minutes of dissolution, and the patient is carried off after a fit of a convulsive kind.

This fever attacks generally on the second, and sometimes the third day after delivery; but it has also occurred so late as after a week. The earlier it attacks, the greater is the danger; and few women recover who have the belly much swelled.

On dissection there is found in the abdomen a considerable quantity of fluid, similar to that met with in peritonitis. The omentum and peritoneum are inflamed, but perhaps very slightly, and gangrene is unusual. The swelling is neither proportioned to the inflammation nor effusion, nor in every instance dependent on these, but on that inflation of the bowels which results from the relaxation of the muscular fibres of the bowels, which is so common in the puerperal state, particularly in puerperal disease. The uterus is not more affected than the intestines. In some cases the thoracic viscera are inflamed. There is the most satisfactory evidence that this disease is infectious, and also that it is epidemic over a greater or less extent of country in particular years.

As it has been confounded by many with peritonitis, it is not to be wondered at if very opposite modes of treatment should be proposed. This attempt to identify puerperal, or, as it has been called, low child-bed fever, with simple inflammation, is practically of the most mischievous nature, and ought to be resisted by all attentive observers of disease.

Early and copious venesection has been strongly advised, as the most effectual remedy; and in a disease which proves so fatal under any treatment, the author has felt it to be his duty, even under many doubts, to make a full and faithful trial of the plan. The result has completely convinced him, that copious and repeated bleeding is a most useless and a most dangerous practice; and if he can prevent his younger brethren from being led away by the plausible arguments which have been adduced in favour of the lancet, he shall have performed an important service to those who are attacked with the disease. He is not inclined to forbid altogether the detraction of blood, but he wishes to limit that practice to those cases where the symptoms of inflammation are the most decided, and particularly to those where the pain is fixed, as, for instance, in the side, or in the uterus; the lancet, in such instances, should be early employed, but ought not to be repeated, and where the symptoms are not decided, it should be altogether omitted. None have recovered who have been largely and repeatedly bled, although the blood was such as is met with in inflammation, and all the recoveries he has met with, have been amongst those who either were not bled at all, or only once, and sparingly.*

Laxatives, bark, and light nourishment, to support the strength, are the most useful internal remedies. In the more advanced stages, wine, to act as a cordial, and opiates, to allay irritation, will be useful. Blisters have been advised, but they are more injurious than beneficial. The application of turpentine is certainly of advantage, and in general gives more relief than fomentations.

If the patient recover, the bowels remain long in an irritable state, and require much attention.

CHAP. XIII.

Of Chronic Swelling of the Abdomen.

It is not unusual, if the patient be exposed to cold after delivery, or have any puerperal disease of an inflammatory nature, for the belly to become swollen and prominent, with some degree of tension. This tumefaction arises from inflation of the bowels, and is dependent on some disease of the uterine appendages, generally of one or both of the ovaria. The connection between the intestines and the uterus and ovaria is well seen, both in the early weeks of gestation, and at the menstrual period, many females about that time having the bowels much distended with air; and this very disease under consideration, may be produced by exposure to cold during menstruation.

It is a complaint of some importance, not only on account of appearance, but also as it indicates the existence of a local disease, or change of structure, which, at some future period, may prove formidable. It is sometimes succeeded by ascites, but much more frequently by that disease improperly called dropsy of the ovarium. In some instances, however, it seems to be entirely dependent on the state of the bowels, at least no other disease manifests itself in future life. When it is not symptomatic of organic affection of the uterine system, it may be sometimes removed by strict attention to the action of the bowels, which is kept up by aperient medicines, administered so as to invigorate, and not weaken the muscular fibres of the intestines. These medicines must be varied according to their effect, and may be combined with tonics, and uniform but

* With us the disease, in its first stage, may be generally considered as of a highly inflammatory nature, justifying copious depletion by venesection and cathartics. J.

moderate compression of the abdomen, or long continued friction every morning and evening.

When it is dependent on ovarian disease, the attention must be directed to the removal of that, which is a matter of great difficulty. The present excellent and zealous Professor of Midwifery in the University of Edinburgh, Dr. Hamilton, has informed the author, that he has, in some cases, been successful, by employing patting or friction externally, and prescribing the solution of muriate of lime.

This chronic swelling is not to be confounded with a tumefaction of a more acute nature, which sometimes occurs in the puerperal state, without pain, or indication of inflammation. The same experienced practitioner compares this swelling to a pillow of down, for, by pressing with the hand, a similar soft sensation is perceived: the hand sinks, but the swelling immediately rises on removing the pressure. It is considered as a fatal symptom.

CHAP. XIV.

Of the Signs that a Woman has been recently delivered.

It is sometimes an object of great importance in medical jurisprudence, to determine whether a woman have lately been delivered of a child. This can be done by examination of the breasts, the external appearance of the abdomen, and the condition of the uterus and vagina. We find the labia and vagina relaxed, somewhat tumid, and of a deeper red than usual. The perineum is generally injured, or the fourchette at least is torn. There is a sanguineous discharge. The uterus is felt to be enlarged, and has neither the shape of the gravid nor of the unimpregnated womb. It generally lies obliquely to one side. The os uteri is nearly circular, is soft, somewhat rugged, and will admit the point of one or more fingers, according to the time which has elapsed since delivery. The belly is prominent, and the integuments lax, wrinkled, and covered with light-coloured broken streaks. The breasts are enlarged, and contain milk, and have a very distinct and dark areola. Many writers on medical jurisprudence, however, consider these signs as fallacious. This, however, is one of the questions, it would appear, which can be more accurately determined by a man of plain sense than by a speculative philosopher. There have been instances where milk has been discovered in the breasts in the virgin state, at least so we are told by authors; but it would certainly be considered as no great proof of virginity, were a female to be found with abundance of milk, suckling a child.

One thing is certain, that the whole of the signs or appearances enumerated cannot exist without a previous pregnancy. A question naturally arises here, May they not be met with when the female has expelled a mass of hydatids, or a mole, as it has been called? This may be decidedly answered in the negative. Most of such substances are produced by conception, but after a time the ovum becomes blighted, and changed into hydatid, or a more solid disorganized mass. As pregnancy, therefore, has existed, it is evident that the secretion of milk and distention of the breasts may take place, and the uterus will be found enlarged. But it is very rare for these masses to acquire such a size as shall enlarge the uterus, or distend the belly, so as to produce such appearances as follow the delivery of a child. And as they are soft, we do not find the same injury sustained by the perineum, or external parts.

Certain cases of suppression of the menses are accompanied with swelling of the belly, and sometimes secretion of a milky or serous fluid in the breasts. But the abdominal tumour arises from inflation of the bowels, and, when removed, leaves no mark on the skin, and cannot have any effect on the state of the vagina, labia, or uterus. Ignorant people suppose, that in such cases of suppression the menses are really retained and accumulated in the uterus, and therefore may enlarge it. This can only happen when the vagina is closed, and in that case relief must be obtained by an operation, the performer of which can bear testimony to the nature of the case.

If in any one instance it could be established that a female had been large, as in pregnancy, and all the signs above enumerated were met with, and particularly when combined with laceration of the perineum, there cannot be a doubt. Granting that hydatids and blighted ova, or moles, could produce the other symptoms, they could not tear the perineum. If such substances really were expelled, they would be shown by the patient, or described by her, so as to satisfy a medical practitioner. Far less can mechanical obstruction of the menses occasion deception, for this cannot possibly injure the perineum, and indeed can only be removed by a surgical operation. Last of all, the absurd account often given by the patient herself must convince every intelligent practitioner of her guilt.

In cases where the mother is dead, and it is necessary to ascertain whether or not she has been delivered of a child, we have, in addition to those marks already described, an opportunity of examining the uterus and its appendages by dissection. The womb is found enlarged, its substance thickened, its cavity filled with coagulated blood, or, if empty, the internal surface is covered with a black coating of blood. The vessels are large, and as they are largest where the placenta was attached, marks corresponding to this attachment may for a time be observed. The extremities of the tubes, but particularly the ovaria, are highly vascular, and these latter contain, on different parts of their surface, vesicles filled with bloody fluid. Can it be determined by dissection, whether a female has had a premature labour, or have discharged a false conception, as it has been called? This is chiefly to be done by the state of the surface of the uterine cavity, and the size of the vessels. After abortion, or premature labour, there is usually some portion of decidua left, and the uterine vessels are large in proportion as the period has been advanced. In blighted ova, or false conception, on the other hand, there can be no portion left of healthy decidua; but, particularly, there cannot be expected the same enlargement of uterine vessels to support a fading or imperfectly organized mass, which would be requisite for a perfect and vigorous ovum. (J B.)

MIGRATION. See Birds Migratory, and Hybernation.

MILAN, a city of Italy, and the capital of that portion which was lately formed into the kingdom of Lombardy by the French, but which formerly constituted the Duchy of Milan. It is situated in a plain, between the rivers Adda and Ticino, from which it is watered by canals drawn from each. One of these canals was commenced in the year 1179, and rendered navigable in 1271: and the navigation is now advancing towards Pavia by a third. This city is about eight miles in circuit. Some of the streets are spacious, and built in straight lines; but many are narrow, crooked, and inconvenient. For the most part they are paved with small marble, or granite pebbles, from the bed of the neighbouring rivers and torrents.

Public buildings are numerous in Milan. The cathedral, standing nearly in its centre, for size and beauty, is considered the finest in Italy, next to St. Peter's at Rome.* It is an edifice in the genuine gothic style, of the largest dimensions, and consists entirely of pure white marble. It extends 490 feet in length, 298 in breadth; it is divided into five naves by 52 enormous marble gothic columns, and it is lighted by five cupolas. The height within under the principal dome is 258 feet; the arches corresponding to which, are 48 feet wide, supported by columns 8 feet in diameter. The pillars supporting the roof are above 90 feet high; and the roof itself is covered with blocks of marble, so closely cemented together by a hard and durable substance, as to appear one entire piece. The principal tower, crowned by a balcony, and ascended by 468 steps, is 400 feet high, affording a magnificent prospect of the city below, surrounded by a fertile country and picturesque mountains. Although this church was begun in the year 1386, the façade, presenting a great variety of ornaments, was never completed until Bonaparte, having resolved that it should be finished in an elegant manner, employed a great many workmen on it. About 4000 statues adorn the exterior and interior of the cathedral, some not exceeding a foot in height. One by the sculptor Agrati, represents St. Bartholomew, who was flayed alive, holding up his own skin as a drapery. It is of white marble, inscribed, *Non me Praxiteles sed Marcus finxit Agrati*, and is esteemed a *chef d'œuvre* of sculpture by the Milanese. But it would certainly be more suitable for an anatomical theatre, than to ornament the interior of a place of public worship. Two large pulpits occupy the sides of the chancel, and near them is a fine organ. Among the other more remarkable objects, is a subterraneous chapel, the place of sepulture of Cardinal Borromeo, Archbishop of Milan, who died in 1584. Seven bass reliefs of silver, forming seven sides of the chapel, represent the principal incidents of his life, executed in a masterly manner: and his body reposes in a shrine, formed of large pieces of glass, with edges of silver gilt. It is arrayed in his pontifical habit; the face exposed, and exhibiting a mortifying spectacle amidst so much grandeur. His hands, in silk gloves, hold a cross, ornamented with diamonds, and a brilliant crown is suspended over his head. The quantity of precious substances buried here exceeds belief. The treasury of the cathedral, besides, contains immense riches in precious stones, gold, and statues of massy silver. But a large proportion of the revenues having been withdrawn by the French, for more useful purposes than sustaining ecclesiastical pomp, the former splendour of this cathedral is diminished.

In its environs is the church of Santa Maria de Morti, a small oratory, which is entirely ornamented with pictures framed of human bones. The church of St. Ambrose, who was Bishop of Milan in the fourth century, and author of very voluminous works, is said to be reared on foundations coeval with himself. But the present structure belongs to the ninth century, and if its doors of bronze be of the same date, they must be different from those which that celebrated father closed against the emperor Theodosius. The pavement is of fine mixed marbles. The vault of the choir is of Mosaic; and the great altar under which the body of St. Ambrose rests, is supported by four beautiful columns of porphyry, enriched with precious stones. The other churches of San Vittore, Santa Maria della Grazie, San Lorenzo, San Celso, are remarkable for size, antiquity, architecture, or paintings. That of San Francesco Maggiore is the largest of the modern churches of Milan.

A considerable number of years ago, this city contained 50 monasteries and 62 nunneries. The people are very devout, for it is common to see a madonna in different shops with a lamp burning before the image until evening.

There are many charitable establishments here, including hospitals, schools, and colleges. The Great Hospital, which receives patients of both sexes, is a spacious building, with a court of above 300 feet square, lined with a double portico, supported above and below by columns of different orders. The whole can accommodate 1500 patients, or even 2000 on extraordinary occasions. Great operations are performed during summer, under a portico open to the street, where the groans of the sufferer are audible to the passengers, and his person would be exposed to their view, were it not concealed by the surrounding crowd of students. A smaller hospital, containing only 40 beds, is better managed: and there is likewise a military hospital. The Lazaretto, environed by a ditch or canal, is a vast quadrangular edifice, 1250 feet in length, and 1200 in breadth, all of brick, containing 304 rooms, with fire-places. A chapel is so contrived in the centre of its court, that divine service may be seen by the sick from their beds.

The college of *Brera*, once belonging to the Jesuits, was more lately denominated the *Palace of the Sciences* by the French, because physic, sculpture, architecture, painting, and engraving, are taught in it. This edifice has a square court, exhibiting two stories, the one supported by Doric, the other by Ionic columns, which are connected by a grand staircase. Here are a good collection of machines, for illustrating the physical department, an observatory, a library, together with a cabinet of 12,000 medals, and a botanic garden.

There are several libraries in Milan, of which the chief is that of the college of Brera, and the next, the Ambrosian, founded by a cardinal of the Borromean family, a nephew of the archbishop above mentioned, in 1609. Its contents exceed 40,000 printed volumes, and 15,000 manuscripts, the former ar-

* See Civil Architecture, and Plate CLXV.

ranged in a spacious gallery, the latter in a separate apartment. Though open daily, and considered a public establishment, this library is always under the direction of the head of the family as its property. Many valuable writings were preserved in it, such as a translation of the works of Josephus, executed 1200 years ago on the bark of a tree; Virgil's Works, with Notes by Petrarch; those of Gregory of Nazianzen; twelve volumes of mathematical, mechanical, and architectural drawings, by Leonardi de Vinci: But the most valuable portion was carried to Paris along with the rest of the plunder of Italy, and it is yet unexplained what has been restored. A library belonging to the Monastery of St. Ambrose is very rich in Latin manuscripts, besides a prodigious collection of charters and diplomas, some of which ascend to the eighth century, the whole being in excellent arrangement.

Literature has been successfully cultivated in Milan; besides Alciati, Beccaria, Carli, Verri, and other authors in history and political economy, this city has been embellished by the names of Pini, Landriani, Frisi, and Donna Maria Gaetana Agnesi, in the sciences. (See Agnesi.) Many valuable works also have issued from the press of Milan, among which may be named the *Historians of Italy*, in 25 folio volumes, by Muratori, published in the earlier part of last century, and the *Classical Italian authors on Political Economy*, in 48 octavo volumes, published in the earlier years of the present century.

The theatre della Scala, which is one of the largest in Italy, was built partly by subscription in 1776, on a magnificent plan. A great vestibule leads to the pit, and two fine staircases ascend to the boxes, of which there are five rows, besides a sixth, or gallery for attendants. The boxes are very spacious, and elegantly fitted up. It is said in a small work, published at Milan in 1817, that sometimes 40 horses and 600 persons are brought on the stage; and the theatre is so skilfully constructed, that the performance is quite audible in parts most distant from the performers. The hour of night is denoted from a transparency on the arch of the proscenium. Besides this, there are several other theatres, one erected after the same model, but smaller, and less decorated, for a French company; and another for the performance of amateurs. Some of the best operas extant have been composed for the theatre of Milan; and some eminent performers are generally engaged in gratifying the public taste for music.

A place of amusement, called the Arena, was lately constructed on the outskirts of the city, for the exhibition of great spectacles, and is capable of accommodating 30,000 persons. It consists of an oval amphitheatre, partly of grassy banks, partly of stone. The lower part of this Arena, which is 400 fathoms long, and 200 broad, may be entirely inundated by means of a small canal traversing it, and there nautical exhibitions, like the ancient naumachia, may be shewn; as was done to entertain Bonaparte.

Milan contains many fine houses: some distinguished by their architecture, others by their spacious apartments and elegant furniture. For the most part, they are decorated externally with lofty granite columns supporting large projecting cornices. That of the family of Litta has a façade with 32 pillars, besides four in the portico.

Much activity prevails at Milan, which is a place of considerable trade and manufacture. Workmanship in metals, embroidery in gold and silver, are executed in a superior style. There are extensive manufactures of silk in its different branches; of wool and goat's hair, glass and porcelain. Mosaic work, and that in pietra dura, is prosecuted on a larger scale, and in greater variety, than in any other part of Europe. Lately a piece of Mosaic, representing the last supper, with figures as large as life, was executed in colours after nature, on six pannels, extending 30 feet in length and 7 in height. It was commissioned by Bonaparte, at the price of 5000*l.* but the overthrow of his government interrupted the work, which has been completed very recently for another sovereign. The fertility of the neighbouring territory, in fruit, grain, and pasturage, affords abundant supplies, both for the consumption of this city, and for export.

Milan consists of 61 parishes, containing 120,000 or 130,000 souls. By some, the population is rated nearly one-fourth higher; and it is said to have been so in the course of the preceding century. In 1766, by actual enumeration, the inhabitants amounted to 111,450, exclusive of those occupying the religious houses, and a certain part of the suburbs. The state of society is considered very agreeable. Frankness and hospitality distinguish the citizens among strangers, and urbanity among themselves. They are devout and bigoted, it is said; but the austerities of monastic life, always calculated to degrade the more amiable sensiblities of mankind, are greatly softened here. A love of show prevails among the higher ranks to a much greater extent than consistent with their fortune, and luxury seems to be making the same inroads as in the other cities of Europe.

Milan, in respect to size, is the fourth city of Italy; its history ascends to a very ancient date; and none has been more exposed to the competition of contending powers; it is supposed to have been founded by the Gauls two centuries later than the building of Rome, whose early history, however, rests on the most uncertain data. In modern times, it has belonged to Spain, Austria, and France; but, although taken and re-taken several times since the French revolution, it was always without bloodshed. When the kingdom of Lombardy was formed by Bonaparte, he was crowned here with the iron crown of the ancient kings of Lombardy; and thenceforth Milan was considered the real capital of Italy. By his order, the fortifications were dismantled, and he built a triumphal arch of white marble, to record his own exploits. Longitude of the Observatory, 9° 11′ 45″ east, and Latitude 45° 28′ 2″ north.

MILBORNE Port, is a borough-town of England, in the county of Somerset. It is situated at the foot of a steep hill, on the river Ive, principally on both sides of the high-road from Yeovil to Shaftesbury. The church is a neat edifice, built in the form of a cross; but the houses, which are disposed in four streets, are, in general, irregularly built, and detached from one another. The guild-hall is an ancient building, with a door-case, partly of Saxon, and partly of Norman architecture. It has considerable manufactures of dowlas, ticking, linsey, stockings, and shoes, which employ a number of hands. The population of the borough and parish, in 1811, was 224 inhabited houses, 132 families, and 1000 inhabitants. See Collinson's *History and Antiquities of Somersetshire*, vol. ii.; and The *Beauties of England and Wales*, vol. xiii. p. 524.

MILE. See Measures.

MILDEW. See AGRICULTURE.

MILFORD, or MILFORD-HAVEN, is the name of a sea-port town of South Wales, in the county of Pembroke, beautifully situated on a small promontory, the sides of which descend gently to the sea. The principal harbour extends to the south, and resembles a large lake. It has sixteen creeks, five bays, and 13 roads. It is regarded as the safest and most commodious in the world, and is capable of holding a thousand sail in perfect security. The town consists of three streets, extending from east to west. The church, which is a handsome building, consisting of a nave, chancel, and two side aisles, stands at the end of the lower row of houses. The old chapel of St. Catharine stands at a short distance to the east, and has been converted into a powder magazine. The market-house and custom-house are neat buildings. Two batteries, each mounting seven guns, have also been erected, for the defence of the town.

The principal trade of Milford consists in its South-Sea whale-fishery, which has been successfully prosecuted by a colony of Quakers, from the island of Nantucket. There is likewise some trade in wood and naval stores. A dock-yard was formed at the suggestion of Lord Spencer, and several large ships of war were built in it, and others repaired. Longitude of Milford steeple 5° 20′ 13″ west, and Latitude 51° 42′ 43″ north. See Corbet's *Geographical Dictionary of Wales*; Fenton's *Historical Tour through Pembrokeshire*; and the *Beauties of England and Wales*. Vol. xviii. p. 755.

MILIARY FEVER. See MEDICINE.

MILITARY TACTICS.

THE art of war may be considered as coeval with the history of the world. The evil passions inherent in human nature,—hatred, envy, covetousness, ambition, and revenge, first gave birth to this destructive art, which, however rude in its commencement, has, in the course of time, gradually advanced to the importance and dignity of a science.

At first, the art was probably limited to the display of individual strength, courage, and address, in wrestling, boxing, and the employment of the most simple offensive arms. But as civilization advanced, and societies became more extensive, larger bodies of men were employed in warlike enterprises; the advantages of a certain degree of order and combination soon became obvious; and experience gradually suggested the use of various instruments, to render more efficient the natural force and activity of the limbs in close conflict, or to annoy the enemy from a distance. The art of war now attained to that state nearly, in which it is still found among the Asiatic tribes, consisting of a mass of rude principles, which could scarcely yet be honoured with the name of science. Meanwhile, there arose men of great talents and ambition, who, being occupied during the greater part of their lives in warlike enterprizes, brought the art to a greater state of perfection, and made use of it as the instrument of their glory and aggrandisement.

Guibert distinguishes five or six great epochs, in which important changes were effected in the principles of military tactics. It was among the Asiatic nations, and particularly among the Persians, that the art appears to have first assumed a systematic form. The Egyptians, attached to the peaceful sciences, made little progress in the military art; and, excepting under Sesostris, they never were a conquering people. After the death of Cyrus, the military art passed to the Greeks; and this brave and ingenious people reduced it to systematic principles, and brought it to a great degree of perfection. Alexander extended it still farther; and, in his time, the Macedonian phalanx was esteemed the most perfect order of battle which had ever been invented by military science.

The principal weapon of the Greeks was the spear or pike, which they used with great skill and dexterity. When in order of battle, the Greeks and Macedonians were frequently drawn up on a depth of sixteen, and even thirty-two men, placed in files, one behind another. This deep and dense order, while it could be perfectly preserved, enabled them not only to resist the most vigorous attacks of their enemies, but to penetrate and lay open whatever opposed them.

The Romans adopted other arms, and a different mode of fighting. Their favourite weapon was a short cut-and-thrust sword, easily manageable in the hand, and admirably adapted to give effect to the courage and activity of their soldiers in close conflict. They rejected the dense order of the Greeks, as incompatible with the use of that weapon, and drew up in long full lines of three men in depth, much the same as in our present European armies; with this difference, that the men were arranged, not in files one behind another, as is now done, but each man in the succeeding rank was placed diagonally, so as to cover the interval between the two men in the rank before them. Besides, the Roman soldier, in order to have the full play of his short sword and buckler, required a great deal more room in all directions than either the Macedonian or modern European soldier. Such were the arms and discipline of the Romans, which, seconded by their courage and skill, enabled them to triumph over the Grecian phalanx, and to maintain for ages the sovereignty of the world.

During the decline of the Roman empire, the science of military tactics was almost entirely neglected, and the empire itself gradually became a prey to those numerous swarms of barbarians whom the hopes of plunder invited to its conquest. For a long period the military history of Europe only presents to our view armies with little discipline and less science; battles gained by numbers, by valour, or by chance; and conquests equally rapid and destructive. Even the invention of gunpowder, although it necessarily occasioned considerable changes in the mode of fighting, does not appear to have immediately led to any very important improvements in tactics.

Maurice, Prince of Orange-Nassau, and Gustavus Adolphus of Sweden, are justly considered as the fathers of modern military science. Both were men of learning and research, as well as of genius; and both carefully studied the art of war in the writings of the Greeks and Romans. Their admiration of the ancients, indeed, was perhaps carried to excess, and led them to the servile adoption of principles, which were no longer suited to the times, or to the arms then in use. But there is no doubt, that we are chiefly indebted to them for the revival of military tactics and discipline. They kept up the prejudice in favour of the dense order of battle, and the use of the pike; but, on the other hand, they shewed the advantages of the oblique order, and invented the present grand basis of military operations, —a triangle resting on a chain of magazines; besides introducing many other minor improvements in the discipline and disposition of the troops.

After the death of Gustavus, Bernhard, Duke of Weimar, Horn, Banner, Torstenshon, Turenne, Montecuculi, and others, fought with success according to the principles of their master; and the art of war continued in certain respects to improve. This, as Guibert observes, was the age of great generals, commanding small armies, and doing great things. Some circumstances, however, still concurred to retard the progress of military science: among which may be reckoned the servile adherence to the ancient tactics, the prejudice in favour of the dense order, and the continued use of the pike, which even the celebrated Montecuculi used to call the queen of arms.

Towards the end of the seventeenth, and the beginning of the eighteenth century, great improvements were made in certain branches of military science, while others were almost entirely neglected. Coehorn and Vauban brought the art of attacking fortified places to a state of perfection wholly unknown to the ancients. The art of defence, however, was far from making equal progress. In the mean time, armies became much more numerous; and the quantity of artillery was prodigiously increased. Louis XIV. gave the example, which was soon imitated by the rest of Europe. Armies so numerous, and with such immense trains, were less easily supplied and put in motion; and the duties of a general were more complicated and more difficult. Condé, Luxembourg, Marlborough, Eugene, and a few other generals of transcendent talents, were able to move these masses; but men of inferior genius sunk under the weight.

Sufficient justice, we think, has never been done to the talents of Marlborough, unquestionably the first commander of his age. The consummate skill which he displayed in the conduct of large armies; the correctness of his *coup-d'œil* in chusing positions, and discovering the weak points of the enemy; his quickness in detecting the faults of his antagonists, and the rapidity with which he took advantage of them; above all, the uniform and brilliant success which attended all his enterprizes, attest the pre-eminence of his military genius. But neither Marlborough, nor any of the other generals of his time, can be considered as inventors in the art of war. They may have made a more or less skilful use of the princples already established; but none of them appear to have introduced any thing new, either in the organization of armies, or in military tactics.

At this period a great schism prevailed in the opinions of military men with respect to the changes necessary to be introduced, in consequence of the use of fire arms. All Europe was divided on the question, whether the dense order of the ancients ought to be rejected, as exposing the troops too much to the destructive effects of artillery? This question was discussed in various writings, without producing any settled conviction. The Chevalier Folard proposed his columns as the fundamental and almost exclusive order for infantry; and his opinion gained many partizans. The army, in short, was on the point of resuming the pike, and forming the phalanx. The war of the Succession, and that of 1733, were conducted upon these unsettled principles; the battalions forming on a depth of from four to six, and the officers of the old school demanding the resumption of the pike, which Vauban had brought into disuse.

We now approach that period, however, when the science of military tactics assumed a more decided and scientific form. Under Charles XII. the Swedish soldiers were still animated by the same spirit which they had manifested under Gustavus. His infantry, hardy and indefatigable, in a state of discipline as perfect as the Roman legions in their best times, and commanded by excellent generals, who possessed a considerable knowledge of modern manœuvres, performed actions which astonished Europe. But Charles was too limited in respect of his means; and his carrer, however brilliant, was too short, to enable us to form a perfect estimate of what he might have been capable of accomplishing under different circumstances; and he has even left us in doubt regarding the extent of his knowledge, and the powers of his genius.

Meanwhile, a new kingdom was formed on the banks of the Oder and the Spree, whose sovereigns having neither commerce nor maritime power, devoted themselves to the creation of a formidable military force, which should enable them to assume an imposing attitude among the European powers. Frederick II. completed the plan which had been chalked out by his predecessors. He not only doubled the number of his troops, but improved their discipline, and invented a system of tactics almost entirely new. He was perfectly well acquainted with the state of the military art among the ancients, and employed his genius in discovering and bringing to perfection such manœuvres as were best adapted to modern warefare. His efforts were amply rewarded by his first successes in the field. But even during peace these efforts were not relaxed. He formed camps at Spandau and at Magdeburgh; exercised his troops continually in the most scientific and effective movements; rectified whatever experience shewed to be defective; and introduced an incredible degree of decision and celerity in the execution of all the necessary manœuvres.

During the seven years' war the efficacy of discipline and tactics, under the conduct of genius, was fully evinced. In the war of manœuvres, as may easily be conceived, the king of Prussia was eminently successful. He was frequently defeated in pitched battles; but he seemed to rise, like Atræus from the earth, with fresh vigour and renewed courage; and it was remarked that he never was more formidable than when his enemies believed him to have been effectually crushed. Such was the state of discipline to which he brought the Prussian troops, that they frequently made forced marches, lost a battle, left behind them the greater part of their cannon, and took up a position at the distance of a couple of leagues from the field where they had been defeated.

But the merit of the king of Prussia does not rest entirely on the improved discipline of his troops; his genius was equally occupied with the scientific principles of military movements; and the Prussian tactics have accordingly been considered as forming an æra in military history. Frederick shewed that the movements of an army of 100,000 men may be reduced to rules as simple as those of an army of 10,000; and that having once discovered the spring which regulates the movements of a single battalion, it is only necessary to combine a number of these springs, and to handle them with skill. He has been considered as the real inventor of light, or flying artillery; but his inventive genius chiefly distinguished itself by his improvement of the oblique or angular order of battle, the principles of which he studied profoundly, and carefully explained its mechanism to his generals.

From the time of Frederick, it does not appear to us that any very important improvements have been made in military tactics. During the late wars, indeed, the French adopted a mode of fighting in some respects new; but this was a necessary consequence of the character of their troops, and their imperfect state of discipline. Instead of lines, that could with difficulty be preserved in the face of an enemy superior in discipline to themselves, they formed close columns. Their battles also were reduced to attacks on certain points, and sometimes on one only. By brigades constantly succeeding each other, and fresh troops supplying the place of those who had been driven back, they generally succeeded ultimately in forcing the point attacked. In their movements, whatever was lost in regularity and precision, was amply compensated by increased velocity. To the rapidity, indeed, with which their movements were executed, they were indebted for much of their success. They also derived great advantage from the employment of numerous bodies of light troops of various descriptions, and the improved and extended use of flying artillery. In their battles, too, they generally kept a large body of reserve, composed of the best troops, and commanded by an able general, which, on more than one occasion, was the means of recovering a battle which was considered as lost.

The French likewise introduced considerable changes in the subordinate arrangements of the army during a campaign. Their wants were supplied by requisition; and when they entered a country they had little or no baggage. By abandoning the old system of forming depots and magazines, they certainly exposed their troops to famine, want, and disorder; but, with all these inconveniences, they appear to have reaped very important advantages from this mode of supplying their armies. Their movements could not be anticipated from the magazines they had formed, and the position of their depots; and their route was not liable to be retarded by the attention which it would have been necessary to pay to these objects. The inroads of the French armies, therefore, were unexpected, and their progress rapid. They calculated only upon success; and they generally obtained it by the celerity of their movements, and the boldness and enterprise of their plans. At the same time it must be observed, that as they generally put every thing to hazard, and neglected or despised those precautions which frequently mitigate the consequences of bad success, their defeats were almost always attended with the most disastrous results. Excepting under Moreau, and one or two other generals, who were attached to the principles of the old school, we seldom find a French army making a skilful and scientific retreat.

The apparent want of discipline among the French troops, their frequent abandonment of the ordinary principles of tactics, and their extraordinary successes, have induced many superficial writers to talk lightly of the whole system of tactical rules and regulations, which science has suggested, and experience improved. We suspect, however, that they have not paid due attention to the real state of the circumstances. The truth is, that, excepting at the earliest period of the revolutionary war, the French troops never wanted discipline, but, on the contrary, they possessed that requisite in a very high degree. They had also the advantage of a great number of skilful officers, educated in the very best school, that of actual service. In the dressing of their troops, as well as in the execution of various manœuvres, they threw aside every thing that was useles or unimportant, and retained only that which was essential, frequently simplifying the principles, and accommodating them to the genius of the nation, and the character of the troops.

The German system of tactics, as established by Frederick of Prussia, although undoubtedly, in some particulars susceptible of modification according to circumstances, will still be found to exhibit the fundamental principles of military science. In this article, therefore, we shall endeavour to present our readers with a compendious view of those principles, following chiefly the order adopted by Mauvillon, in the third part of his *Introduction to the Military Sciences*. At the end of the article we shall also subjoin a list of writers, whose works we have occasionally consulted, and to whom we would refer such of our readers as are desirous of acquiring more minute information on the subject.

Writers on military tactics have generally divided the subject into two parts. The first, or *Tactics*, strictly so called, relates to the composition and discipline of an army, and to those dispositions which are requisite for its security and regular supply, and to render it efficient for service, without an immediate reference to the actual presence of an enemy. Under this head are also comprehended practical tactics, or the rules to be observed in the conduct of detachments, and also castrametation, or the art of encamping on the field. The second explains the general principles upon which the operations of an army are conducted against an enemy in the field; or what is technically called *Strategics*. This division of the subject has been objected to by some; but for the sake of method, we have resolved to adhere to it, although we are willing to admit that the limits of each division have not been very precisely defined.

Part I. TACTICS.

Sect. I. *Of the Composition of an Army.*

An army consists of an indefinite number of armed men, assembled together and placed under a certain state of discipline, for the purpose of carrying on war. It may be divided into Infantry, Cavalry, Artillery, and Engineers.

The infantry consists of regular infantry of the line, and light infantry. The infantry of the line was formerly divided into grenadiers, fusiliers, and musquetiers. This division was founded upon certain differences in their arms and modes of fighting, and is now no longer in use. The grenadiers, however, are still retained in all services; they are selected for their size and strength, and are principally employed in enterprises requiring great force and courage.

The arms of the infantry consist of the musket and bayonet; formerly they had also side-arms, but these were found to be more ornamental than useful. The proper length and construction of the musket have not hitherto, perhaps, been precisely ascertained; the practice of different nations varies in this respect; but the perfection of this weapon consists in the largeness of its calibre, its durability, its projectile force, and the correctness with which it carries the bullet. The utility of the musket, as a warlike weapon, has been greatly increased by the addition of the bayonet, which enables troops thus armed to come to close combat. The use of the bayonet was first introduced by the French, about the end of the 17th century, and it has since become general.

To enable the soldiers to use their arms, and at the same time, to render the enemy's artillery less destructive, the infantry is placed three deep, so that they can fire at once and behind each other. Each man occupies a space of about two feet in rank and file, a sufficient interval being left between the files to admit of the freedom of individual motion.

As in the case of individuals, all kinds of troops can attack and defend themselves only in front. Every number and description of troops, therefore, must be placed so as to attack in front, and to be liable to be attacked in front only.

Their arms afford the infantry a twofold mode of fighting. They either endeavour to throw the enemy into confusion by their fire, or they march rapidly upon him, charging with the bayonet, in order to break his line. As the firing generally carries off so many of the troops, that a part of the line is either entirely broken, or much weakened, before the armies approach near enough to each other, a charge, or at least an actual combat with the bayonet, seldom takes place, except in extraordinary or accidental circumstances. The French boasted much of their success with the bayonet in their late battles; but the way, it is believed, was always pretty well cleared by their numerous artillery previous to the charge. In the hands of British soldiers, the bayonet has always proved a most efficient and decisive weapon, as they have always, indeed, been distinguished for their courage and firmness in personal conflict.

In order to facilitate the government and movements of an army, it is divided into small bodies of men, called battalions, consisting of from five to seven hundred men. Each battalion is provided with two field-pieces; and when several battalions are placed together, they preserve as much distance between them as is necessary for the management of the field-pieces, and to enable persons to ride through conveniently. With cannon attached, the interval between batallions is twelve paces; without cannon, it may be six paces. A greater interval is always a consequence of necessity. In large armies, several battalions are formed into brigades, several brigades into divisions, and these divisions into larger bodies, called *corps d'armée*, each placed under the immediate command of officers of a certain rank.

Infantry are capable of acting upon every species of ground, and are therefore the most essential constituent of an army. It is thought dangerous, however, to expose infantry to the attacks of cavalry upon a plain, where the latter are always most efficient, and the former are liable to be broken, especially if they should attempt to put themselves in motion. But recent results seem to have demonstrated, that a well disciplined infantry, properly disposed, are, in such a case, not only capable of opposing a successful resistance to cavalry, but even of becoming the assailants in their turn. In all broken and uneven ground, such as hills, woods, villages, behind hedges and fences of every description, rivers, morasses, and all kinds of entrenchments, infantry can be most effectually employed, both for attack and defence.

The following are general rules for the disposition of infantry upon different kinds of ground.

1. On hills, infantry must be posted so as to command the whole declivity; and therefore they must not always be placed on the very highest ridge, or summit, much less behind it, if the object be to oppose the ascent of the enemy.

2. When a wood is to be occupied by infantry, they should be placed on the edge of it, so as to be concealed by the trees, while, at the same time, they are enabled to fire upon an approaching enemy. A combat with infantry of the line can seldom take place within a wood, unless where an attack is made upon a detachment posted there to obstruct an enemy's passage, or in light open places.

3. In villages, the infantry, when numerous, occupy the hedges and fences of the gardens, or orchards, outside, so as to command the fields beyond them. When attacked in this situation, they retire gradually from hedge to hedge, and occupy the gardens themselves, with the houses and streets within their line. The same rule applies to farms and fields that are subdivided by hedges or other fences. As the regular infantry always fight in a body, and in line, care must always be taken, in occupying hedges, villages, &c. to preserve a communication in every direction, in order that one part may support the other, and that the whole may always form one connected line, impenetrable to the attacks of the enemy.

4. Infantry are posted behind rivers, morasses, ravines, &c. in order to prevent, by their fire, the passage of the enemy. For this purpose, it is by no means necessary to occupy the whole length of the bank, but only to be posted so as to keep all those places where the enemy can effect a passage, at the distance of a short gun-shot, under their fire, and that fire, if possible, a cross one.

The regular infantry lie in the field under tents, which are carried on baggage-waggons, or on horseback. Every battalion carries along with it two field-pieces, and the necessary ammunition. As in the course of an active campaign they are not quartered in towns and villages, they must also carry along with them several other necessary articles, which swell their baggage to such a considerable bulk, as frequently proves an impediment on service.

Of light infantry, there are a great many different kinds, with an almost endless variety of designations; such as riflemen, sharp shooters, or tiralleurs, chasseurs, voltigeurs, &c. In some services, the troops of certain nations are especially destined to the duties of light infantry. Light infantry differ from regular infantry, principally in their arms, equipments, and mode of fighting. In their arms there is less difference now than formerly, only that those destined to act as riflemen are armed with rifles, instead of common fire-locks. Their baggage is less bulky than that of the regular infantry, and they have no field-pieces attached to their battalions. Their mode of fighting is less regular than that of the infantry of the line, and requires more individual skill and intelligence. In what is called the *petite guerre*, especially in mountainous countries, this description of troops is most eminently useful. In the late war, the French appear to have brought the light infantry service (for which the character of the people seems peculiarly adapted.) to great perfection. It frequently happened that their light troops were enabled, by the vivacity of their movements, to harass, exhaust, and ultimately subdue more numerous bodies of regular infantry.

The cavalry are composed of heavy and light horse. The former may be divided into cuirassiers and dragoons. The cuirassiers only have defensive armour, viz. a cuirass or iron mail, which protects the breast and back. In the British, and some other services, there are no cuirassiers. Indeed, it has been found, that the cuirass is of little use, and, on the contrary, proves a great impediment to the free motion of the rider. The dragoons are armed with a sword, a carabine, and a pair of pistols. The cavalry are placed in two ranks, although the first only can act immediately against the enemy. The second line, however, tends to give more firmness to the whole body, and can supply the places of those who fall in front. Their manner of fighting consists in endeavouring to throw the enemy into disorder by the *impetus* of their attack, and then to cut them down with their swords. Every thing therefore depends upon their preserving order with the greatest possible celerity of motion. The cavalry, as well as the infantry, are placed in small bodies, called squadrons, at certain small intervals from each other. A squadron generally contains from 120 to 160 horse.

Cavalry, and especially heavy horse, can only be employed in a champaign country, and on firm ground; but there they are capable of acting not only against cavalry, but also against infantry, and even in the attack of batteries. The celerity with which they are enabled to perform their manœuvres, renders them peculiarly well calculated for all decisive movements, such as cutting off, or turning the enemy, falling unexpectedly on his flanks or rear, &c.

Dragoons were originally a mounted infantry, who were employed in all enterprises requiring speed. They sat on horse-back, but frequently fought on foot. Even to this day, they are still armed and exercised with a view to being employed as infantry in a case of necessity; but they are almost never used as such, and are therefore to be considered solely as cavalry. In default of light horse, their duties must often be performed by the heavy dragoons.

The cavalry carry their tents on horse-back along with them. The horses stand in the field, in the open air, and are picketed in lines before the tents in which the riders lie. As the cavalry have no cannon, and carry almost every thing they want upon their horses; in which care must be taken not to overload them; they are, on this account, not liable to have their motions impeded by their baggage. They are more frequently, however, embarrassed by the care of providing for the maintenance of their horses. They must provide forage for themselves, taking it either from the fields in summer, or from the magazines or villages in spring and autumn. The former is called green, the latter dry forage.

The light cavalry have smaller horses, lighter arms and accoutrements, and less baggage than the heavy horse. In foreign services, particularly the German, the light horse are generally called hussars, and are clothed in a manner corresponding to the name. In the British service also, there are several regiments of hussars. The mode of fighting peculiar to the light cavalry, consists generally in constant skirmishing, either advancing or retreating. But when well disciplined and efficient, they should be able, when necessary, to charge in close order, and to execute all the manœuvres of the heavy cavalry.

The following are some general rules for the service of light troops, whether infantry or cavalry.

1. They should keep as near the enemy as possible, in order to ascertain the intention of all his movements; and, 2. They should follow him in all his movements. 3. They should constantly engage in enterprizes against him, by carrying and occupying posts, intercepting convoys, destroying magazines, harassing the enemy on all sides, and carrying off stragglers, &c. 4. They should pursue the enemy when beaten, and hinder his pursuit when victorious. 5. They should bring contributions and supplies from a distance; and, 6. They should endeavour to conceal the movements of their own army. For this purpose, they form a chain of posts in front, and on the flanks of the army, which must support each other, and be able to retire upon their main body. The different species of troops, in these operations, must be placed so as to enable them to act most advantageously: The cavalry in plains, and accessible places; the infantry on irregular ground, in tenable places, and behind entrenchments.

The artillery consists of cannoneers, bombardiers, sappers, miners, and pontooners. The cannoneers and bombardiers serve the cannon, and a certain number of them are attached to every piece. As they do not fight like other troops, they are, in general, only provided with side arms; sometimes, however they carry other weapons, to be used on occasions. Sappers and miners are employed only in sieges, and are armed with pistols and daggers, which the latter use under ground. The sappers are seldom required to use arms of any kind, which with them, therefore, are more ornamental than useful. Their duties consist more in exposing themselves than in giving personal annoyance to others. The same applies to the pontooners, whose duty it is to attend the pontoons, (a kind of small copper boats,) which are carried in waggons behind the army, in order to throw bridges over rivers, and they must therefore possess all the skill requisite for this employment.

The horse-artillery, or flying-artillery, are of recent introduction, and were first employed, with great effect, by the French, in the late war. They had no field-pieces attached to their battalions, but this deficiency was amply compensated by their numerous horse-artillery. The best and most skilful men are selected for this service, and being mounted, they are enabled to act with great expedition, and to move rapidly to any part of the field. The horse-artillery are divided into troops, as the field-artillery are into companics. The men are armed with large sabres and a pair of pistols; some of them also with rifles.

The engineers are particularly useful in conducting all the scientific operations of war. They are generally divided into fortress-engineers and field-engineers. The former are employed in the construction of fortifications, and in conducting the attack and defence of fortified places. The duties of the latter consist in surveying, reconnoitering, or drawing plans of positions, directing the movements of an army during a march, choosing proper ground for encampments, constructing field fortifications and entrenchments, and pointing out the proper mode of attacking the fortified positions of an enemy. See FORTIFICATION.

Besides the various descriptions of troops already enumerated, almost every army is attended by a number of guides and pioneers The business of the former is to point out the best roads for an army on march; that of the latter to render the roads passable, by removing obstructions, &c. The sappers and miners are employed in digging out ditches, and constructing other works, in order to facilitate the approach to a fortress, and in excavating the earth, and undermining the ground, for the purpose of blowing up some part by the explosion of gunpowder.

The staff of an army consists of all those officers, to whom is confided the care of commanding, directing, and providing for the troops; such as the general commanding, the quartermaster-general, adjutant-general, commissary-general, provost marshal, physician and chaplain to the forces, &c. with their respective aides-de-camp, deputies, assistants, &c.

The fatigues and dangers of war render it necessary to establish lazarettos and hospitals, with a requisite number of physicians and surgeons, for the care of the sick and wounded. Such of the sick as are dangerously ill, and require a tedious cure, are placed in the lazarettos, which are generally situated in towns and villages at some distance from the army. Others, whose cases are more slight, are placed in the flying-hospitals, which follow the army, and require an hospital-train.

Spies are also necessarily employed by an army; that is, persons who, for money, endeavour to ascertain and communicate the circumstances and intentions of the enemy. These may be people belonging to the country occupied by the enemy; persons who go in disguise to procure information; or persons from among the enemy themselves, who are bribed to discover all that they know. Spies must always be well paid, especially in the last mentioned case, and their information should be received with great caution, and compared with that obtained from other quarters. Spies giving false information, must be severely punished, unless, perhaps, we may be able to turn this circumstance to our own advantage.

SECT. II. *Of Castrametation.*

The art of castrametation, or the choice of ground for a camp, and the disposition of the various descriptions of troops in it, was formerly a matter of infinite consequence in war. Of late, however, it has become of much less importance, as troops, at present, seldom carry tents along with them, but are placed in cantonments when intended to be kept in readiness for the field, or when obliged to lie in the field for a short period, they have recourse to the *bivouac*.* But although regular encampments are now much less frequent than formerly, it is necessary that we should explain the principles of castrametation, because these are applicable, not only to the choice of situations for camps, but also for positions in general, and will be found of especial use in determining the order of battle for an army acting chiefly on the defensive.

There are two general and fundamental rules for the choice of a camp. In the first place, the situation of the ground should be such that an attacking army can derive no benefit from it; and secondly, such disposition must be made as to secure the camp from being surprized.

In order that the enemy may derive no advantage, but the reverse, from an attack on the army encamped, the following special rules must be attended to. 1. The ground for the camp must neither be too large nor too small. 2. The enemy must not have it in his power to approach either on the flanks or the rear. 3. He must not have the power of making a sudden attack on the front without meeting with immediate resistance. 4. The approach to the front must be difficult, and on his advance, the enemy must, at every point, be constantly kept under a stronger fire of artillery than he can oppose. The more difficult the approach, the stronger is the camp; and when difficult of access at every point, it may be said to be unattackable. 5. Every part of the army encamped must be able to come to the assistance of the rest. 6. The outlets from the camp, on every side, must be easy.

With respect to the size of the camp, the following observations may suffice. 1. Its length must be equal to the space occupied by a battalion and a squadron under arms. In determining the length of the camp, however, according to this method, provision must be made for the intervals formerly mentioned, which, if necessary, when the whole number of troops are not there that the space would require, must be reckoned larger; but at the same time, never larger than the front of a battalion and squadron, which is called the half line. 2. An army is never encamped in a single line, but in two, at the least, with some picked troops in reserve behind the second line. 3. In order to determine immediately in what situation of the line each battalion should be placed, an order of battle for the whole army is formed at the commencement of every campaign. The regiments are thus placed according to their rank or number; the first on the right, the second on the left wing of the first line, the third on the right, the fourth on the left wing of the second line, &c. When a battalion or squadron is detached from the line, the others close, and occupy its place. It is always easy, therefore, to determine the necessary length of the camp, according to the number of battalions and squadrons in the first line. 4 To determine the depth, it must be observed, that each line requires three hundred paces for the depth of its encampment, which is also the distance assigned to them when drawn up in order of battle, that the second line may not suffer from the fire on the first.

The second rule we have laid down requires that the

* Troops are said to bivouac, when they lie out without tents or regular covering from the weather. As troops now carry no tents, this sometimes becomes a matter of necessity.

flanks should be covered. The flanks are said to be covered, when the enemy can neither attack them directly, nor march round that which covers them, without leaving full time for taking measures to frustrate his intentions. Hence we must determine the fitness of the objects upon which the wings rest. The wings may rest on the sea. In this case we must ascertain the depth of the water, and, if necessary, protect the wing by a staccado, or some such means, as far as the water is so shallow as to allow a person to wade through it. Regard must also be had to the changes produced by the ebb and flood tides; and care must be taken to prevent the army from being annoyed by the ships or boats of the enemy. 2. On rivers, which afford an excellent support to the flanks of an army, when there are few or no natural or artificial means of passage; and the few are sufficiently protected from the enemy. 8. On lakes or ponds. The extent of the circuit which the enemy must make to get round must determine the fitness of these objects for covering the flanks. 4. Swamps or morasses also afford a good covering, provided we are certain that they are impassable. 5. The same may be said of mountains and ravines, when very precipitous; but when easily ascended, they ought to be fortified. Ravines form a good covering when the banks towards the enemy are lower than those occupied by the army encamped. They should, however, be fortified and occupied, in order to prevent a surprise. 6. Woods afford no good covering, even when ambuscades are placed in them, because the enemy may approach unseen, and easily overpower the ambuscade. 7. Villages, when well situated and tenable, are a good covering for the flanks; but they must be well fortified, and occupied by a sufficient number of troops to prevent an attack on the part of the enemy, because the safety of the army depends on their being maintained.

In following out the third rule, it is necessary, that, to the distance of a cannon shot in front, there should be no wood, village, hill, hedge, or other object, to obstruct our view of the enemy's movements;—no ravine, or hollow way, which could lead him unseen near to our front. Every thing must be quite clear before the front, and the enemy must be exposed to our fire, while all his movements are so well seen that we may always be prepared against any enterprise on his part. Such objects, therefore, as above described, when they do exist, must either be destroyed, or occupied, and fortified.

The fourth rule has much in common with the first, because whatever covers the flank also protects the front, the flank being always secured against every attack; while, when an attack is expected in front, it is sufficient that it be rendered difficult. An army is never encamped with the front to the sea, unless to prevent a landing; and in that case we must endeavour to concentrate the fire upon those points, where the nature of the coast is favourable for a descent. Ponds, lakes, and inundations, so far as they cover the front, present such obstructions as render it unattackable. A river is also a great obstruction, the greater in proportion to its breadth and depth, the paucity of fords or bridges, and the more those situations at which the enemy can cross are exposed to our fire. A perfect morass renders the front unattackable, and it also affords a good covering when it cannot be passed without difficulty. Woods in front are of no use, but rather a disadvantage, because they conceal the motions of the enemy. Glens, ravines, hollow-ways, &c. are a great protection to the front, when they run parallel to it; but when they run at angles into the camp, they must be occupied along their length. Villages, when tenable, and lying near the front, may be of great service; but the directions formerly given with respect to those objects, must be attended to. Single houses, castles, and other buildings, lying before the front, must be occupied so as to enable us to maintain a fire upon all that comes within a gun-shot of the troops.

The fourth rule requires that no river, morass, ravine, or considerable hollow-way, or impassable wood, should run through the army, much less between the two lines. When such objects occur, sufficient and permanent communications must be made over them, according to circumstances.

The sixth rule requires that regard be had to the object we have in view. The rule is, that as soon as an army enters the camp, roads must be made on all sides, to enable the troops to march out conveniently. But in all circumstances this rule cannot be observed. For a strong camp, affording at the same time facilities for marching out, will not easily be met with. If the object, therefore, be to have the facility of marching forwards on the enemy, less attention is paid to the strength of the camp. If, on the other hand, it be our intention to await the attack of the enemy, less regard is paid to the facility of marching out in front, provided only that the march towards both sides, and especially towards the rear, be open and convenient.

Finally, it is obvious, that if there be heights in the neighbourhood of the ground where we wish to encamp, the camp should be placed on them, and not in the low grounds.

In order to secure a camp from surprise, it is necessary to establish posts and field-guards. These posts must be placed in such manner, and at such distance, that the army, in whatsoever order it may happen to be, may be enabled to prepare for defence before the enemy can make their attack. They must therefore form a chain round the army, each supporting the other, so that nothing can pass through unobserved. They consist of infantry or cavalry, with light-troops, or troops of the line. On plains, and where objects can be seen at a considerable distance, cavalry are posted; but in broken ground, infantry are required. A post of light horse must be supported by one of heavy cavalry behind; which last is also supported by light or regular infantry. In woods, behind hedges, &c. light infantry are commonly placed; the regular infantry in villages, houses, and, last of all, behind entrenchments. Every large post places a smaller one at some distance, but in such a manner as not to be liable to be cut off. The sentries of all these posts, two of which always stand together, must be able to see and hear each other. The cavalry posts are frequently placed at greater distances during the day, and drawn closer at night. The field-guards of the cavalry are placed, not for fighting, but for watching; as soon, therefore, as a superior enemy approaches them they must retire. The infantry posts, on the other hand, are almost always placed so as to be able to maintain their ground, and therefore they ought generally to defend themselves as long as they can, in order to give more time to the army to prepare for defence. As soon as any danger approaches a post, or is observed, notice must not only be communicated to the proper quarter, but when forced to retire, the circumstance must be made known to the next post.

Every camp should have a facility of obtaining supplies of water and wood, and the army should also be provided with the necessary forage for the first few days a least. Care must be taken, therefore, that the wells, ponds, springs, &c. be not wantonly spoiled, nor the forage in and around the camp.

The camp is generaly marked out before the arrival of the army. For this purpose, the regimental quarter-masters, with the pioneers of the regiments, and some detached troops, march in advance under the conduct of the quarter-master-general. The latter having chosen the situation for the camp, and determined, according to its length, how many paces should be allowed to each battalion or squadron, including the intervals; the aides-de-camp then assign to each regiment, according to the number of its battalions and squadrons, its proper place in the first, second, or third line; after which the regimental quarter-master sets off the ground for each, according to a scheme established in the war-order of every nation, by marking out the space of each tent, those of officers as well as of privates, with stakes. When the army enters the ground, every battalion marches to the front of its encampment in order of battle; the tents are erected, and the camp is complete.

The main principle in encampments is, that the army be placed in the same order as for battle; so that nothing more is necessary than to march out ready for fight. But as this principle is not always without exception, such measures must be taken as shall enable the army to make the necessary alterations in its order of battle, before an actual attack is made by the enemy. In order to be enabled to form more rapidly, and also to encamp in places where there is otherwise a want of depth, the king of Prussia, to whom the art of war is so much indebted in modern times, invented what has been called the method of encamping in order of battle; in which there are no passages for the companies, and the tents are placed close together in three rows for the three lines.

Sect. III. *Of Foraging.*

By foraging is meant bringing in food for the horses, when it is done by the cavalry themselves. Forage, as we have already observed, is either green or dry.

The first thing to be done in foraging is to ascertain, whether there be forage sufficient for the number of horses. In dry foraging, therefore, the magazines are inspected; in green foraging, an experienced officer is sent out to reconnoitre the quantity. This officer endeavours to ascertain how much corn and hay are contained within a certain space, which he measures by the square steps of his horse. He then prepares the field, and determines the number who can forage upon it, deducting one-third of the whole space for the spots upon which nothing grows. Practice renders this task very easy, and will enable one to determine the quantity, as well as the extent, tolerably well merely by the eye.

An order is then issued to the army, or to that part of it which is intended to forage, to have their foragers ready at a certain time and place, in order to forage for so many days. When there is to be a general foraging of the whole army, it must first be ascertained that nothing is to be apprehended from the enemy while the people are out. Otherwise the army forages by flanks, in order that they may be prepared to resist the attack of the enemy in the camp.

When foraging is carried on under cover of the army, nothing more is necessary than to see that order, temperance, and proper discipline are preserved, which, however, requires great attention. The foraging itself is conducted in the following manner: When the forage is green, a particular spot is assigned to every regiment, when their foragers dismount, and set to work by fours, while one holds the horses. The former reap the corn, bind it up, and place it on the horses. The rider then mounts, and when they are all ready, they march off by regiments; first the artillery, and other trains, then the infantry, and last of all the cavalry. In dry foraging, the villages are assigned to the regiments, from which they are to forage; and it is best when the peasants are made to bring together outside of the village what they are required to provide, which is then divided; by which means all excesses are more easily prevented.

If an attack upon the foraging party is apprehended, they must be covered by a force proportioned to that of the enemy, the extent of the foraging ground, and the means of defence which it affords. It should consist of heavy and light horse, with infantry. The relative proportion of these troops must be regulated according to the nature of the ground.

The covering force should march on the previous evening, and occupy the ground which is to be foraged. The chain is afterwards formed in the morning, while the foragers leave the camp. When the covering force marches at the same time, and at the head of the foragers, no man should be allowed to dismount and commence reaping until the chain is formed, and the order is given by the commanding officer.

As soon as the light troops, preceding the party, arrive upon the foraging ground, they carefully reconoitre the neighbourhood, to ascertain whether there be any places where the enemy might lie concealed, such as woods, villages, ravines, &c. Bridges, and other approaches, must be occupied by a strong party. Cavalry and infantry posts are then placed, who must form a chain of centries, who allow none to pass the limits for the purpose of foraging, and give immediate notice of every thing that approaches. These posts are established on the same principles as those round a camp; and this is called the chain, which, however, is only formed in this manner in green foraging. When the light troops and posts give notice that the enemy is no where to be seen, the commander orders the foragers to dismount. He places himself with his corps either at the most important station, or if more than one attack is apprehended, in such a situation, as will enable him conveniently to oppose the approaching enemy at every point. When the ground is of considerable extent, he divides his corps into divisions, which he places at the most dangerous points, so that they can always afford assistance to each other. But when he hears or perceives that an attack is made in any quarter, he ought not to hasten thither immediately with his whole corps, but must only engage so far as is necessary to oppose the force employed by the enemy; because the attack may be merely a feint. So long as the enemy does not appear in superior force, the commander must always endeavour to complete his foraging; but when the enemy is too strong, the foragers must be immediately sent to the rear without their forage; the chain must be drawn together, and the whole covering force make its retreat in the best possible order. In dry foraging, the dispositions are much the same, only that it is unnecessary to form any proper chain, as the forage is brought to one spot, and the men, therefore, are kept better together; and, indeed, the whole business is much less complicated.

Sect. IV. *Of Marches.*

As it is extremely difficult even for a single battalion to march to any distance straight forward in order of battle, this may be considered as impossible in the case of a whole army. It is necessary, therefore, to break the order of battle when setting out on a march, and to proceed in many files behind each other, with as small a front as convenience, or the nature of the road, may require. This is called marching in columns. If nothing were apprehended from the enemy, this might be performed without any great nicety. But as it is necessary to be prepared against every possible attack, and the enemy can be resisted successfully only when received in order of battle, there are certain rules which must be observed in marching. In the first place, the march must be so arranged, that the troops may be at any time placed in order of battle, in the most rapid manner possible. Secondly, all precautions must be taken, according to the description and number of the troops, and the nature of the ground, that the enemy may not be able to attack us before we are prepared to receive him in order of battle. According to these principles, the disposition to all marches, whether of large or small bodies of men, must be regulated.

The ultimate principle of these movements will be found in the evolutions of a single battalion, or what is called petty tactics. Petty tactics are nothing else than the art of placing a battalion or squadron, as rapidly as possible, in order of battle, out of every given position; and in that order which the nature of the ground, and the position of the enemy requires. A short review of these rules is a necessary preparation for the science of marches.

In most services, the battalion is divided into four divisions, and eight platoons; and this division is the foundation of all movements. When under arms, each man occupies a space of about two feet in rank and file, and the whole are placed in three ranks. But upon a march, it is impossible to proceed in such condensed order. Each man then requires the space of three feet on all sides. All step out with the same foot, and march regularly. The length of every step, from heel to heel, is generally thirty inches; and, in ordinary time, seventy-five of these steps are to be taken in one minute. In quick time, one hundred and eight such paces are taken in the minute; and in double quick time, one hundred and twenty. When the word is given to step out, the length of the step is about thirty-three inches. Experience proves that a quick march is incompatible with the preservation of order even for a short space. The quick marches, therefore, are only used in sight of the enemy, or when the troops are exercised to it on parade. In ordinary marching, the soldier is not required to keep exact time and cadence.

All changes of the order of battle of a battalion on the spot, consist in forming front to the rear, or to either side. The changes on a march are to place the troops in column, and to march forward, backwards, to either side, in an oblique direction; and in all these varieties of marching, to place them in order of battle towards any side at pleasure.

To form front to the rear, is most easily effected by facing to the right about. The third rank then becomes the first, and the whole position of the battalion is reversed. It is easy for the officers to change their places according to this alteration of position. If it is intended that the entire order of the battalion should remain unchanged, it would be necessary to bring round the front by a counter-march of the whole; a movement which, with a whole battalion, would require considerable time, even were it performed at the double quick step. (See Plate CCCLXXXI. Fig. 1.) If it be wished that the order of the rank only should be preserved, each platoon might be made to counter-march in itself; by which, however, the platoons would be thrown round, which has its inconveniences. (Fig. 2.) To make a whole battalion wheel about, is a movement much easier conceived than executed; besides, that it would then occupy a different position. (Fig. 3.) If performed round the centre, then one half of the battalion would be obliged to wheel backwards; while, on the other hand, it would be better that one half, before the wheeling, should face to the right about. (Fig. 4.)

Many methods may be imagined of forming front towards the flank. 1. The battalion faces to the right or left, and either form entirely by marching up, (Fig. 5.) or by deploying. (Fig. 6.) 2. By a single quarter wheel. (Fig. 7.) 3. By each company making one-eighth wheel, with the exception of the flank company forming the centre, which makes an entire wheel; towards which the others then march straight up to the flank of their next platoon, and take their proper place in the new front. (Fig. 8.) This is the only method at present practised. In all these methods the troops might be made to wheel equally well round the centre. (Fig. 9.)

There are two methods of placing the troops in column. 1. By forming in column; and, 2. by wheeling with any parts of the battalion at pleasure. In forming in column, the whole battalion, with the exception of the head division or section, faces to the right or left. All march off at once, in order to place themselves, according to their order, behind each other, and all behind the head or leading division. (Fig. 10, 11.) The reverse of this is deploying, in which a battalion in column places itself again in order of battle by a contrary movement. A battalion may also be formed on the centre, and the deploying likewise be performed from the centre; the one half of the battalion facing to the right, and the other to the left. (Fig. 12.) In this movement, it will be observed, 1. That the intervals between the divisions are almost entirely done away; and, therefore, that the wheeling cannot take place separately, nor, in case of a bend in the road, without making a halt; first behind, and then again before, in order that the rear sections may have time to advance. Farther, a troop, standing thus in column, cannot, without a tedious movement, form front to the flank. Finally, it is impossible, according to this method, to form in column upon a very small front; and if this were to be done by several battalions, it would not only cause the last battalion to go a considerable way to no purpose, but would often be attended with difficulties. The forming into column by wheeling is performed by each section of a battalion making a wheel of one quarter by itself; so that they all stand behind each other at intervals, corresponding to their front. When, after wheeling, the battalion marches so that the first platoon forms the head, it is called to the right; but if the wheeling has been to the left, and the eighth platoon has the head, they are said to march off to the left. (Fig. 13, 14.) In this manner, the march may take place, not only to the flank, but to the front, or the rear. In marching to the flank, all the sections wheel to the right or left, and march off at once. In marching forwards, all the sections wheel, except the one which forms the head, which marches straight forward; and as soon as it has passed the second section, the latter wheels again towards the opposite side, in the true line of march, and follows the first; the others, in the same manner, follow the second, wheeling as above, upon the same spot. (Fig. 15.) In marching to the rear, the head section makes a half, the others a quarter wheel. All the sections then march straight forward; and when the second is exactly on the spot where the first has just made its half wheel, the latter wheels again into the new line of march; and the like is done by the others, as they arrive at the same spot. (Fig. 16.) In the same manner a perfect counter-march may be executed; the head section making immediately a three-quarter's wheel; and the others, as they arrive at the same spot, making a half wheel. (Fig. 17.)

From this method of forming in column, the following advantages are derived. 1. When the road becomes more narrow, so that it is necessary to break off, this, as well as the march forwards again, can take place without halting. (Fig. 18.) 2. The column can instantly form front to the flank, merely by wheeling inwards, which is of great advantage, when any thing is apprehended from the enemy in that quarter. 3. The march proceeds immediately without farther preparation; and the columns may be formed on as large or as small a front as we please. The only disadvantage attending this method is, that it requires a tedious movement to place the troops in order of battle to the front of the column, whether this is performed by filing, which besides can only take place on the ground with a long column in a large plain; or by marching up, especially if the head section arrives first on the ground where it is intended to remain. In order to unite all possible advantages, it is usual to make the troops commence the march while the columns are formed by wheeling. On approaching more to the enemy in front, divisions are formed at half distance, which at length advance altogether, in order to place themselves thereafter in order of battle, by deploying in double quick time. The most simple mode of marching towards every side, and in all directions, is the flank march, with facing to the right or left. When moving under arms, in the neighbourhood of the enemy, and at short distances, this method is extremely useful; and the troops ought to be particularly well exercised in it. But it is not adapted for marches in general, because the columns would require to be immensely extended, in order to enable the soldier to march in this manner without constraint. For this reason the method has been invented of facing to the right with five or six, which is a mode of forming columns by wheeling with quarter platoons, very convenient on narrow roads, and which leaves room enough for the soldier to march unconstrained. The oblique march can be performed on very small distances by stepping out to the right or left, and the oblique step. On larger distances, it is usual to keep the two small sides of the right angled triangle, although it might be possible to wheel by sections into the direction of the large side, and preserving the respective distance and situation of the sections among themselves, to march into the new front, and then to wheel inwards again. (Fig. 19.) In proper marches, the sections wheel into the line of march, and afterwards step into the road precisely behind the first.

In order to place troops standing in columns in order of battle towards any side, the following rule must be observed: When troops are placed in column without intervals, the forming front forwards is executed by deploying to the right; when all the divisions, except the last, face to the right, and march in double quick time to the flank of their next division to the left, the command is given: Halt front, march, dress! the last division only marches straight forward. (Fig. 20.) In deploying to the left forwards, the first division remains on the spot, and the others perform the above movements reversed. In deploying from the middle, the divisions in front of the middle one face to the right, and those in the rear of it to the left. The division which remained in its place marches forwards into the alignement of the most advanced; the others form front, advance into the alignement, and dress. (Fig. 21.) When the troops march off to the left, and the last division forms the head, all the above movements are then reversed. (Plate CCCLXXXII. Fig. 22.) In forming front to the rear, all that is necessary previous to deploying is, that each division counter-march in itself. (Fig. 23.) To form front to the flank, or in an oblique direction, when the columns are placed without intervals, is a manœuvre not easily performed without creating disorder. The head division would be obliged to wheel into the proposed alignement, and the others then face to the right or left, place themselves behind it, and then deploy in the usual manner. (Fig. 24, 25.) When the battalion has been formed into columns by wheeling, it may be placed in order of battle to the front, by marching up; (Fig. 26.) but this must always be a tedious movement, because, in order to preserve the distances, it must always be performed in ordinary time; and it must be still more tedious, when the troops have marched off to the right, and up to the left. (Fig. 27. It is usual, however, to form divisions, and then to advance and deploy. (Fig. 28.) If it be intended to form front to the rear of the march, and that by marching up, if the troops had marched off to the right, all the sections might be made to face to the right about, and then march up to the left, so that the battalion would then stand precisely so, as if it had faced to the right about. Or each section may be made to counter-march in itself, and then march up to the right, (Fig. 29.) or deploy, (Fig. 30.) so that the battalion stands exactly in its usual order. If the troops have marched off to the left, it is easiest to form upon the right flank, and *vice versa;* and herein consists the advantage of this kind of march. (Fig. 31.) It is equally easy to form left to left, and right to right, if it be not objected that the battalion stands with reversed front. (Fig. 32.) If it be only intended to bring the first rank forward, it is only necessary to make the sections wheel inwards, towards that side. (Fig. 33.) But if the usual order of the battalion is to be completely preserved, with the first platoon upon the right flank, the whole must counter-march, while the first section wheels to the right about, and all the rest after it, as they arrive at the spot. Now, when the first platoon arrives at the place of the last, and the last upon that of the first, they wheel inwards. (Fig. 34.) But if it be intended, when the battalion stands thus in column, to take an oblique position, it is only necessary that the sections should advance or retire, by the right or left, round the point about which the column is to turn, taking care always to preserve their proper distance, and then to wheel inwards as soon as they arrive with their flanks in the new alignement. (Fig. 35, 36) In the flank-march, a battalion can instantly form the proper or reversed front to the flank of the march. It is a more tedious operation to form front to the front or rear of the march; but this may be very easily performed, either by coming round, if the battalion is to be placed towards that side where the third line stands; or, if it is to be placed towards the other side, by a double marching up,—the one in the diagonal line, if the ground be clear behind; the other, by making each soldier go along the two small sides of the right-angled triangle formed by his position in march and that which he takes up in the order of battle. This last is very useful in marching up close to a defile; and it is also the basis of what is called the bridge-manœuvre. (Fig. 37.)

As it is necessary, however, that a battalion, as soon as it arrives in the neighbourhood of the enemy, should be placed in order of battle, and so advance, frequently through difficult ground, it must not be permitted to break its order at every obstacle, but when any such presents itself, the part of the battalion which comes before it should face to the right or left, and hang on the rear of the march, and afterwards immediately march up into the line, when the obstacle is passed. (Fig. 38.)

Before we quit this branch of the subject, we must briefly notice a very celebrated mode of placing troops, which has been frequently adopted, but of which the utility in actual service has been much doubted, viz. the *battalion quarrée*, or square. There are various methods of forming the square; one or other of which may be preferable upon particular occasions, according to the facility of its execution, the nature of the ground, the attack to be sustained, &c. In Miller's *Elements of the Science of War*, the reader will find eight different methods described. (Vol. II. pp. 54, &c.) In the neighbourhood of the enemy, the sides proceed by the flank-march; but when unmolested they may prosecute their march broken into quarter sections.

It is scarcely necessary to observe that the movements we have described above are not executed, upon a long march, with the same precision as upon parade. The principles, however, are the same; and the officers must not only march in their proper places, but must not suffer the different sections to get into confusion, or extend too far in length; so that on the first signal, all may take up their respective positions, and proceed in proper order. We now proceed to the more general arrangements which are necessary for an army on a march.

If an army were to form a single column, and to march to the right or left, to the front or rear, it would occupy, especially with baggage and artillery, far too long a line, and would require too much time to form in order of battle. Hence it must form more than one column. The number must depend upon the nature of the ground, and its relative situation with respect to the enemy. The following rules, however, are to be observed. 1. In marching forwards towards the enemy, or rear-wards from him, it is of advantage to form as many columns as the ground will admit of, because the troops can be placed more speedily in order of battle, according as the columns are more numerous, and consequently shorter. The ground will admit of as many columns as there are good roads. But the desire of having many columns must not induce us to assign to any one too difficult a road, because whatever detains one column is a hindrance to the whole army. 2. When only a few columns can be formed, all our precautions must be doubled, in order to prevent an attack from the enemy, or, at least, to have sufficient time to receive it in good order. 3. When on a march our flank is exposed to the enemy, it is necessary to march by lines, in order that each line may be able to form immediately by wheeling. This measure, however, must depend very much upon the degree of probability of a sudden attack from the enemy. For if it be known that he cannot make a sudden attack, it is more convenient for the army to march in several columns.

As to the arrangement of the columns, it must depend, in a great measure, upon the nature of the ground. The general rule is: To encamp as we would fight, and to march as we would encamp. But to this rule there are exceptions. In marching through woods and hilly ground, the cavalry must not form the outward columns, but should march under cover of the infantry. The artillery and baggage should always have the most secure road. In marching forwards or backwards, the columns are always composed of portions of both lines. In marching forwards, the regiments of the first line generally form the head; and in marching to the rear, they follow those of the second.

For the security of the march, the following precautions are taken. 1. In marching forwards, a strong advanced guard precedes the army, which, according to the nature of the ground, consists either of many cavalry and few infantry, or *vice versa*, and of light troops. The latter explore the country through which the army is to march, on all sides, and to as great a distance as possible, in order to give timely notice of the approach of the enemy, &c. The other troops not only support the light troops, but also cover the army in its march, against the enemy's detachments, drive back such of the enemy as come in their way, and keep him in check by their manœuvres, when he advances with his whole force, until the army has time to place itself in order; for which reason they frequently carry cannon along with them. In marching backwards, or retiring, a rear-guard is appointed, in the same manner, and for a like reason. Its nature, strength, and distance from the main body of the army, must depend upon the nature of the ground, and other circumstances. Both must be able, by their movements, and by the position of their detached posts, to cover all the columns of the army against every hostile attack. In the flank-march, troops must be placed on that side where the army has any thing to apprehend from the enemy, in order to cover it; and light troops must carefully reconnoitre at a distance towards the enemy. 2. The baggage in a march must always be covered by the army; in marching forwards, it should be placed behind, and in marching backwards, before; in the flank-march, it should be placed on that side on which no hostile attack is to be dreaded. When no attack whatever is apprehended, it may be placed close behind or before the columns; or even, when in perfect security, between the regiments. 2. At other times, however, it is frequently sent forwards to a distance, or left entirely behind. 3. When marching in full expectation of an attack, the artillery is distributed by brigades among the columns of the troops, in order that it may deploy at the same time with them. At other times, the park has its peculiar column. 4. The columns must never cross each other on a march, nor approach too close, nor remove too far, from each other; the engineers who direct the route must attend to the former,—the commanders of the columns to the latter. 5. A defile is, every road, or part of a road, where it is not only necessary to break off, but where it is impossible to form in order of battle. In breaking off, upon these occasions, a stoppage is always occasioned: Hence the other columns must regulate themselves by that which has to pass such defiles. But if the whole army must pass them, no part must be allowed to proceed, until we are certain that nothing is to be apprehended from the enemy, so long as we are occupied with the passage.

For the convenience of the march, it is requisite, 1. To prepare as many good roads as can be got ready for the army, and to avoid defiles as much as possible. The artillery, indeed, must have the firmest and most convenient road; but the cavalry also must avoid morasses, woods, steep hills, ravines, and such like, and rather take a circuitous route. With infantry, on the other hand, regard is principally had to the shortness of a road, and to the facility with which the soldiers can march upon it. 2. Care must be taken in passing defiles, that the troops pass speedily, and in regular order; and the head, when out of the defile, should not be allowed to run on, but should shorten their pace. For nothing fatigues troops more than the constant change from halting to running, which is unavoidable in the irregular passage even of the most trifling defile. 3. The marches ought not to be too long, nor too rapid; and all unnecessary circuits should be avoided. 4. All the columns, so far as is possible, should march out of the old encampment, and into the new one, at once; and no part of the army should have a perceptibly longer or shorter route than the rest. 5. For the convenience of the army, the fourriers and sharp-shooters are sent on with the advanced guard, in order to mark out the camp, that the troops may march into it without delay.

On every march, an order is issued, containing an exact description of the number of the columns, and the troops of which they consist; of the strength and composition of the advanced or rear-guard, or the flank covering parties and patroles; of the precise route of each column, and all else that is to be observed during the march.

Sect. V. *Of Convoys.*

An army does not always carry all the necessary supplies along with it; nor is it always in a situation to receive these supplies from a distance, without the apprehension of their being cut off by the enemy. When supplies, therefore, are to be brought by a road to which the enemy has access, the convoy must be covered by a party of troops. This is one of the most difficult operations in war; because even a small convoy—suppose one hundred waggons—will occupy a line too considerable to be easily covered by a small body of troops. The strength of the covering party, however, must be regulated chiefly by the probable operations of the enemy. It consists generally of cavalry, infantry, and light troops; but the description of troops must depend much upon the nature of the ground.

An advanced guard precedes the convoy, which bears a certain proportion to the whole covering party. The infantry occupy all the villages, bridges, woods, &c. through which either the convoy is to pass, or an attack is to be apprehended from the enemy. The light troops scour the country in front, as far as they can with safety, and examine every place in which the enemy might conceal themselves. In a flat open country, the cavalry of the advanced guard spread out, to cover the convoy in front, and to support the advanced parties of hussars; but always in such a manner, that they can easily draw together, and unite to oppose the enemy. A part of the covering party marches in small sections beside the convoy, either on both sides, if both are exposed to an attack from the enemy, or, as is generally the case, only on one side. While the convoy is passing along, all the approaches are kept occupied, and the light troops continue to examine the country around.

The convoy must also have a rear guard, which follows at a proper distance, and has its light troops behind. The infantry relieves all the posts of the advanced guard and the flank-covering party, and occupies them as long as is necessary. On plains, the cavalry covers the rear of the convoy by its manœuvres.

A large convoy occupies so much ground, that it is only possible to cover it against an attacking enemy, when the latter approaches by a way which is known in sufficient time to admit of their passage being opposed. Otherwise, it is necessary to make the convoy drive up, in order that it may occupy less space. In this case, the different posts and detached parties must be at such a distance from the convoy, as to give sufficiently early intelligence of the approach of the enemy; and they must also do every thing in their power, by defensive operations and manœuvres, to detain him. In passing a defile, the convoy must drive up before entering it. An investigation must then be made, as far as possible, to ascertain whether any attack is meditated by the enemy, and if none is apprehended, the passage commences, after a proper proportion of the covering party has been advantageously posted on the other side of the defile. The waggons, as they effect their passage, drive up again, the remainder of the covering party then passes, and the whole proceed in their march. In all situations where it is intended to rest, the waggons must be driven up, and form a barricado; the horses placed within, and all the necessary dispositions previously made for the protection of the convoy.

When an attack is to be made by the enemy, the convoy should be formed into a barricado, in an advantageous position, as, for example, with one or two of its sides leaning on a village, on a large strong building, a river, a wood, a ravine, &c. or upon a height, which the enemy must climb before he can make an attack. In order to form this barricado, the carriages are driven up close to each other, and the troops place themselves behind, and fire. The cavalry are advantageously placed in the vicinity, in order to molest the enemy during the attack. Shold the enemy, however, attack with cannon, more especially with howitzers, the defence of the convoy in this manner could hardly prove successful. The best plan, in such circumstances, would be, to advance towards the enemy, to take an advantageous position between him and the convoy, in which he would be compelled to attack us, and there to fight him. But even upon this plan the convoy must be driven up; for to cover it on a march by such a manœuvre could only be practicable in extremely favourable and rare circumstances, in respect to the situation of the ground, when the enemy had only one approach to the convoy, and that one capable of being occupied and defended.

Sect. VI. *Of Detachments.*

By a detachment is meant a body of men sent to act separately from the main army on some particular service. It may consist of infantry or cavalry, or of both; sometimes it is composed of light troops only; but in general some of these are combined with the others. The number of men comprehended under the name of a detachment cannot be accurately determined; but when several battalions and squadrons are combined, they are called a detached corps.

The object for which a detachment is sent out must determine the description of troops to be employed, as well as the conduct which the leader has to pursue. The reasons for sending out detachments may be reduced to the following: 1. To carry a reinforcement to some particular quarter. 2. To occupy a post which is necessary for the security of the army, or to keep up the communication. 3. To execute some enterprise against the enemy. 4. To procure information by means of prisoners, or otherwise, and to reconnoitre.

The description of troops to be employed on a detached service must be determined by the nature of the ground, and by the object to be accomplished. If a post, such as a village, a bridge, an entrenchment, &c. is to be attacked or occupied, the detachment should consist of infantry. If rapidity be the chief requisite, it should consist of cavalry. When the situation and the object seem to require a different kind of troops, dragoons, who can serve on horseback or on foot, may be employed with advantage.

The general rules for every detachment are: 1. To obtain correct information relative to the views of the enemy, in order to provide for our own safety. 2. To form an advanced guard, in proportion to the strength of the detachment, for the purpose of reconnoitring in front. For this service, as well as that of flank patroles, light troops are especially useful. The nature of the ground must determine to what distance this advanced guard should proceed, but at all events it must not run the risk of being cut off. 3. Such objects as woods, villages, ravines, heights, growing corns, &c. must not be passed, without being certain, from a strict examination, that no party of the enemy is concealed among them. 4. On entering a defile, the whole troop must be drawn together, and not venture in, until all the neighbourhood has been searched, and we are sure of being able to pass and form, before the enemy can attack us. 5. In retiring through such a defile, the detachment should leave a party behind to occupy it, which is afterwards drawn off. The duties of such a post are, to investigate and give notice of every thing that can interest the detachment, and to oppose every attack as long as possible.

I. With regard to the object in view, the special directions for a detachment which is sent somewhere as a reinforcement are, 1. To march secretly, if necessary, which requires a very accurate knowledge of the country, in order that the troops may proceed under cover of woods, or other objects. The patroles, too, should be instructed to observe the enemy without being themselves seen. 2. Should the detachment fall in with the enemy, it should, whether stronger or weaker, employ all kinds of skilful manœuvres, and even artifices and stratagems, in order to avoid fighting. 3. If it be impossible to avoid fighting, the detachment must endeavour, by a skilful, prompt, and determined attack, to beat even a superior enemy. 4. The following reasons only can justify a commander in retiring or abandoning his object: An order to do so, on the occurrence of certain circumstances; the obvious impossibility of a successful result, in consequence of the superiority of the enemy; or if the object could no longer be accomplished, even after a successful attack on the enemy. 5. Should the attack succeed, and the enemy be put to flight, the detachment should not think of a keen pursuit, but should immediately proceed to the accomplishment of its object.

II. A detachment intended for the security of the army, or to occupy a post with the view of keeping up the communication, must observe the rules above given on its march, and also the following, when it has arrived at its destination. 1. It must secure itself by entrenchments, according to circumstances, against every attack. 2. It must place its out-posts so as that none of the enemy may pass unperceived along any part of the district which it is intended to cover. 3. When the out-posts are insufficient, this object must be effected by means of patroles. 4. The small detachments of the enemy which would interrupt the communication must be dispersed; the larger ones must, if possible, be opposed; and the advance of a much superior enemy should immediately be notified at the proper quarter, the retreat made on orders received, or the post defended until reinforcements arrive.

III. A detachment may be sent either directly against the enemy, or may accidentally encounter him, in attempting to accomplish its proper object. In the latter case, all the rules above-mentioned must be observed. In the former case, the detachment must carefully avoid all the enemy's parties, excepting that against which it is directed. Great caution must be used in marching during the night, in order that the enemy may not be unexpectedly encountered, so as to frustrate the whole plan. If an enemy's party is met, and cannot be avoided, all means must be used to surprise it, without firing a shot. When the time for attack has arrived, it must be made with promptitude and resolution, in order to bring the affair immediately to a decisive issue. If any obstacle occurs, a determination must quickly be formed, whether it be of such a nature as to frustrate the whole plan, and render a retreat necessary, or whether the plan may still be accomplished, and in that case the attack should be made without loss of time. The object of the detachment should be steadily kept in view, and the commander should suffer nothing to divert his attention from it, even should an opportunity offer of striking a blow unconnected with that object; for in this one may often be dreadfully deceived; and the best praise of an officer is, to execute well and faithfully what he has been commanded to do.

IV. Detachments sent for the purpose of collecting information respecting the enemy, by reconnoitring, or by means of prisoners, must approach the enemy directly, but cautiously; and when they meet any of his parties, if not too strong for them, they should immediately attack and beat them, and make prisoners; but beware of a blind pursuit, lest they fall into an ambuscade. Should they encounter a party superior in strength to their own, they should keep up a skirmish, without being drawn into an engagement, and, if necessary, in retiring; and by every sort of artifice, they should endeavour to make prisoners, with the view of accomplishing their object.

All detachments, on returning from the execution of their object, should secure their retreat by marching in close and regular order, and keeping their men together, by appointing a rear guard to cover their rear and flanks. Should the rear guard announce the approach of the enemy, the detachment must immediately endeavour to gain a place of safety, by some skilful manœuvre, such as a retreat *en echiquier*, if the troops are of the same description, or forming into empty or solid square, when infantry have to retire before cavalry; or they must take advantage of the ground to continue their retreat; or, finally, endeavour to get rid of the enemy by a sudden and resolute attack.

Sect. VII. *Of the Attack of Foraging Parties, Convoys, and Detachments.*

In all such attacks, it is necessary that we should be well informed of the dispositions of the enemy, that we may take our measures accordingly. Two general rules are particularly to be observed. In the first place, we should make the attack with a superior force; and, secondly, we should make it unexpectedly, which is best accomplished by laying an ambuscade.

An ambuscade is a concealed body of troops, who wait the approach of the enemy, and fall upon him by surprise. The choice of a place for an ambuscade, as well as the number of troops to be employed, must depend upon circumstances. Buildings, woods, heights, ravines, corn fields, are fit places for laying an ambuscade; but care must always be had, that the troops may be able to sally out upon the enemy without defiling. The place must be approachable by a concealed way, or occupied during the night. Every thing must be avoided that can tend to betray the ambuscade; such as the glancing of arms, neighing of horses, &c. and sentinels must be placed in such situations as enable them to see to a distance round them; but they must lie upon their bellies, without hats or caps, or other covering for their heads. The ambuscade must be surrounded at all the approaches by outposts, to guard them carefully, and stop every thing that comes near them. Not a shot, however, must be fired; and the posts must be regularly visited, but without noise. Should the ambuscade be discovered, it must be transferred, if possible, to some other place; but if that is not possible, and an attack is in any degree practicable, it should be made without delay. Otherwise, the enemy must be allowed to approach as near as possible, and should not be attacked until he is entirely in the hands of the ambuscade. In all cases, the attack must be made as rapidly as possible, but in perfect order; and with this view the troops should be previously taught how and where they are to sally out. The cavalry must attack with their swords at a gallop; and the infantry with the bayonet, without firing.

In consequence of the multitude of light troops employed in modern warfare, it is not so easy to lay an ambuscade now as formerly. For this reason, such attacks are often made without attempting an ambuscade. The following are the special rules to be observed in these different kinds of attack.

The number and description of the troops to be employed in the attack of a foraging party must be determined by the time and place, and by the strength of the enemy's covering party; its green foraging is generally performed in plains; a numerous cavalry will here be most useful; but infantry must also be employed to support them, and likewise for the attack of posts. Whether an ambuscade has been laid or not, an attack is generally made first at one place, in order to induce the enemy to weaken his chain at other points, where a second attack is then made. If the enemy be cautious, more than one attack must be made simultaneously, in order to distract his attention, and enable us to penetrate some parts of the chain, which is always the main object. The attacks must, therefore, be made in a very lively and vigorous manner. Having succeeded in penetrating the enemy's chain, the light troops should endeavour to take as many prisoners as possible, and particularly horses. If the enemy, however, has made good dispositions, and placed the foraging party in safety, they must be pursued so far in their retreat, as to render it impossible for them to return and complete their foraging.

The attack of a dry foraging party requires farther dispositions, and a stronger body of troops, especially of infantry. The principal object here is, to attack the villages in which the enemy is foraging, and which are all occupied by infantry. To do this successfully, it is necessary to attack them all at once. A great object has been gained, if we prevent the enemy from completing his foraging; and this much may be accomplished by a vigorous attack: For it will probably happen, either that the enemy shall send his foragers back to quarters, from apprehension; or they will escape of themselves. When this has been accomplished, and the covering party do not retire, they must be kept in constant alarm, until the foraging can no longer proceed; but care must be taken not to engage so deeply as to run the risk of being beaten, especially if the enemy has, in the mean time, received reinforcements. Should the covering party retire, they must be pursued so far as possible, in order that they may give up all thoughts of returning; and then all sorts of carriages should be put in requisition, in order to carry off the forage, which the enemy had collected, to our own quarters.

In attacking a convoy, without laying an ambuscade, the attack must be made, if possible, before the enemy is fully prepared. If he be on the march, an attack is made first on the advanced or rear guard, in order to draw the troops towards that quarter. Several attacks are afterwards made at different points, particularly such as the enemy has weakened, in order to oppose the first attack. Should he, however, be prepared at all points, several attacks must still be made, with the view of distracting his attention, and in order that the light troops may have an opportunity, in the intervals, of penetrating the convoy, and inflicting as much injury as possible. These attacks may be the more easily hazarded, because, if unsuccessful, there is no chance of farther loss; for the enemy's attention being occupied by the protection of the convoy, there is no difficulty in getting away from him.

If the convoy be encamped, the first thing to be done is to get rid of the supporting cavalry; and then, by means of a superior fire, or a vigorous attack upon a weak part, to penetrate the barricado, as in the case of an entrenchment. But if the covering party have taken up a position in front of the convoy, and there await the attack, we should examine whether it be possible to get round behind them, in order that, while we make a feigned attack, a part of the troops may in this way get among the convoy, and destroy it. Should this be impossible, the covering party must be attacked like any other post.

In attacking a detachment, it may be proper, in the first place, to make use of an ambuscade, because the leaders do not always take the necessary precautions. The enemy should then be enticed into the ambuscade by means of a body of troops, who first advance and then retire, or even betake themselves to flight. If the enemy have to pass a defile, we should endeavour, by occupying it, to cut off his retreat, and then, under cover of a ravine, height, wood, &c. to get on his flanks or rear, in order to attack him suddenly in front and rear, or in the flanks. This must never be neglected, when the enemy, by the slightest degree of carelessness, gives us an opportunity for executing the stratagem. Such are the measures to be taken by a detachment, which has been sent out for the purpose of attacking another. The commander, however, although his march may have been ever so well concealed, must not neglect any of the necessary precautions for his own safety. If two detachments, however, which have been sent out for different purposes, should happen to encounter each other, a prudent commander will endeavour notwithstanding to secure all the advantages above described, and will also employ every means of obtaining early and correct information respecting the views of his antagonist, in which the attachment of the people of the country will be of the greatest service. But when two hostile detachments suddenly encounter each other in front, without either having taken the necessary precautions, the numbers, valour, and discipline of the troops, must decide the victory, which will generally be in favour of the party that makes the most determined attack. Should a weaker, however, encounter a stronger detachment, the former must put on a good face, and endeavour, by taking every advantage of the ground, and executing skilful manœuvres, either to hold out until reinforcements arrive, or to make a good retreat. But when a stronger detachment encounters a weaker, the former, indeed, should circumstances permit, ought to endeavour to beat the latter, but at the same time to beware of too much keenness, for fear of falling into an ambuscade.

When prisoners and booty are made in such enterprises, they should be sent forward for security, and the troops should follow, in order to protect them against a possible pursuit, but without engaging farther with the enemy, unless in a case of necessity.

Part II. STRATEGICS.

Sect. I. *Of the Knowledge of the Country.*

As no military enterprise can well succeed without a knowledge of the country in which the operations are to be carried on, it is necessary that we should say something respecting the best means of obtaining this information. The knowledge of a country embraces three things, viz. its political, economical, and military circumstances. All the three are in some measure useful to the soldier; the last may be considered as indispensable.

This information may be obtained by means of printed, manuscript, or verbal descriptions; maps, charts, or drawings; or by personal enquiries. There are few printed descriptions of countries, indeed, so minute and accurate in their military details as is requisite for warlike operations; but in other respects they are often extremely useful; and should be studied, on account of the other material points of useful information which they contain. Historical works, especially such as are written with a view chiefly to military operations, and also the lives of celebrated generals, are of much use, and should be studied with great attention.

No opportunity should be neglected of collecting written and oral accounts of lands, whether in time of war or peace. It must be observed, however, that during war the sources of oral accounts are frequently suspicious, and little to be depended upon, either from ignorance or design in the individuals from whom the information is obtained. To expiscate the truth, therefore, requires much care, skill, and knowledge of human nature.

Maps and charts, plans and sketches, are of singular use in a military point of view. Their value must depend much on the greatness of the scale upon which they are constructed, and the accuracy and minuteness with which the objects are laid down. Maps afford a view of entire countries, their limits, the position and distance of the principal towns, the course of the rivers, &c. and are indispensably necessary towards obtaining a general knowledge of the relative situation of all the parts. Plans and sketches are more limited; and when accurately constructed, they should give a faithful portrait of the objects. A good military sketch should represent every object in its real position and proportion; it should distinguish the nature of the ground, the position and form of the heights, the size of the plateau, the woods, rivers, with their windings, bridges, fords, &c. Also the roads, defiles, towns, villages, churches, and even single buildings, &c. The name of each individual object should likewise be marked. The more minutely the nature of the several objects is described, the more useful will the sketch be; because an apparently trivial circumstance is frequently of importance in a military point of view.

Individual investigation may consist in the preparation of a sketch or description of the district, or merely in making a reconnoissance. In both cases, a practised eye, and a knowledge of the military application of objects, are essentially necessary.

Sect. II. *Of the Plan of Operations.*

Before an army takes the field, it is necessary to draw up a general plan of operations, otherwise much time would be lost at every step in deliberating upon what was to be done next. The perfection of a plan of operations depends almost entirely upon an accurate knowledge of the country in which the war is to be carried on.

War may be conducted either offensively or defensively. The former plan is generally adopted by the stronger power, the latter by the weaker.

The strength and composition of the army to be employed must be determined according to the strength of the enemy, the nature of the undertaking, and also the nature of the country. If it be intended to act offensively, the force employed must be stronger than that of the enemy—the more so the better. But even in a defensive war, the force employed ought never to be so small as to be incapable of contending with the enemy. In an open champaign country, it is necessary to have a considerable force of cavalry, especially, to enable us to carry on defensive operations with success. In mountainous districts, on the contrary, a numerous and effective infantry are required; and a light infantry will be found particularly serviceable. In general, according to circumstances, the cavalry form from an eighth to a fourth part of the whole army. The quantity of artillery must depend upon the nature of the undertaking. If there are many fortresses, a large battering train will be required; and in a country possessing many tenable posts, it is necessary to have a numerous field train, which must be drawn by good horses, in order not to detain the army in its movements. An army should always have a large body of light troops; and although the nature of the ground may make some difference necessary in the proportion of these to the troops of the line, yet it is not easy to determine the proportion according to any precise general rules, because light infantry are useful on many occasions, and light horse may be extremely serviceable even on broken ground.

In conducting offensive operations, two cases are to be distinguished. In the first place, the object may be to surprise the enemy, either at the commencement of the war, or on the opening of a campaign. Secondly, it may be intended to make an attack upon an enemy who is prepared to receive us. The first case is evidently the most advantageous; but, in order to insure success, it is necessary to keep the enterprise secret, and to execute it with the greatest possible celerity.

When it is proposed to surprise the enemy at the commencement of a war, it is necessary not only to have a considerable number of troops constantly on foot, but that these troops should be in a state fit for immediate service. Baggage and artillery horses must be in readiness; a large store of war ammunition must be prepared in the neighbourhood of that quarter where the war is to be commenced; and magazines must be formed for the maintenance of the troops. All these preparations, too, must be made with such care, that the enemy may not be able to discover the object. When all the necessary preparations have been made, it must then be determined what are the most decisive measures that can be accomplished by a surprise; how far we can get the start of the enemy; and whether we shall have sufficient time to execute the most decisive measure, or must be content, from want of time, with something less decisive. These questions must be determined according to the circumstances of each case. Among the objects to be accomplished by a surprise are the following: To seize the enemy's capital; to take possession of one of his most important provinces; to separate his army, so as to prevent it from being drawn together; to attack one of his principal allies, and force him to make peace. When none of these most important objects can be accomplished, we must endeavour to obtain possession of the means of prosecuting the war with advantage, by occupying the passes which lead into the enemy's country, or making ourselves masters of a river which opens into it; or by carrying a fortress which affords the key to it, &c.

In all such enterprises, however, we must keep in view the means of defence which the enemy can oppose to us. These, in general, are: 1. Fortresses; 2 Rivers; 3. Defiles; and 4. The army itself. In the first case, the whole undertaking will commence with a siege of the most important fortress. The importance of a fortress depends upon the advantages which the possession of it will afford us, or the disadvantages to which the loss of it will subject the enemy. Sieges, therefore, must never be formed, unless, 1. When the fortresses are placed on the passes which lead into the enemy's country, and in such a manner that you cannot penetrate till you are masters of them. 2. When they are on your communication, and the country does not furnish the necessary subsistence. 3. When they are necessary, in order to cover the magazines you form in the country itself, to facilitate your operations. 4. When they contain considerable magazines of the enemy, and such as are essentially necessary to him. 5. When the conquest of them is necessarily followed by that of some considerable district, which enables you to separate your armies into winter-quarters in the enemy's country. All fortresses, which are of no essential use in our farther advance, or to our safety in case of a retreat, should be demolished as soon as they are taken.

Rivers and defiles may be passed without difficulty in the case of a surprise; but they should be passed at such places as lead most safely and directly to the great object, where posts may be established, to enable us to advance, or, if necessary, to secure a retreat. If the nature of the country be such, that it can be covered by the army alone, that is, if it be an open country, we must immediately push forwards towards that object, which, if attained, will prove decisive of the war,—as, for example, the capital; or, if that be impossible, we must begin by occupying some tenable place, for the purpose of establishing magazines, of enabling us to advance, or to maintain the conquered country, or to secure a retreat.

In the case of a surprise at the opening of a campaign, we can never expect to find the enemy so unprepared as at the commencement of a war. It is necessary, therefore, that such an undertaking should be previously well considered; for as troops are called upon, in such a case, to act at a season when they are exposed to great hardships in the field, we ought to calculate whether the probable success will compensate the certain expence of men and money. There are occasions, indeed, when the advantage of a few days over the enemy may be decisive; and these should never be overlooked. But when several weeks are required, it will be found much better in most cases to let the troops rest, and wait for the time when the war may be prosecuted without any such evident waste of our recources.

If we cannot attack the enemy otherwise than in a state of preparation, we must endeavour to penetrate into the country in spite of his army. For this purpose, it will be necessary for us to force his army at that point, which will lead us most safely and immediately towards the object we have in view. This may be effected, 1. By a diversion, that is, by causing an attack to be made in some other quarter, so as to make him draw off his troops, or weaken his army at that point where we wish to penetrate. This method is generally adopted, when the enemy has taken up a strong position which covers the whole country; or when we wish to undertake a seige, but are prevented by the strength and advantageous position of the army opposed to us. In order to render this method effectual, however, it is necessary that we should have a sufficient superiority of force, and that our diversion should threaten great danger to the enemy. 2. By intercepting and cutting off his supplies. This may be done, by establishing posts on the rivers or passes, by which he receives his provisions; or by constant attacks on his convoys and foraging parties, which requires a great superiority in light troops, especially cavalry. 3. By means of detachments, which is a species of diversion. 4. By manœuvring, that is, by marching and countermarching in such a manner as to threaten the enemy in some other quarter, and, while he makes corresponding movements in order to oppose us, to seize the occasion of his weakening the point at which we wish to force him. 5. By bringing the enemy to a battle, which is the most simple of all methods. But as a battle is, in many respects, more liable to chance than any other military enterprise, and the enemy will naturally always endeavour to take up a strong position, a prudent general will rather try every other means, if possible, unless he perceives the probability of obtaining extraordinary advantages from fighting.

To lay down a plan of operations for a defensive war, and to carry it into execution, are matters of much more difficulty. A skilful general, therefore, will always endeavour to seize some opportunity of converting a defensive into an offensive war, by striking such a blow as will give him the superiority over the enemy. As in a defensive war the difficulty consists in our being generally obliged to regulate our movements according to those of the enemy, of which we cannot always obtain sufficiently early intelligence, it is necessary, in laying down a plan of operations for a defensive war, to anticipate the probable undertakings of the enemy, according to the nature of the country, and to take proper measures for opposing them. If, for example, the defence of a country depends upon fortresses, these must be previously supplied with all necessaries, and the positions must be determined from which they are to receive succour, when threatened. If it depends upon the defence of a river, or other defile, the positions necessary for its defence, as well as the means of defending it, must be previously taken. When the defence rests upon the army itself, posts and tenable places must be prepared for it; and much prudence will be required in selecting such as are most advantageous; otherwise the covering army must be made sufficiently strong as to enable it, under a skilful commander, to assume an offensive attitude. In a defensive war, the following general rules are also to be observed: 1. We must be in a situation to take the field in such good time as to oppose any enterprise on the part of the enemy. 2. Every precaution must be taken, in order that the army may find supplies at every point to which they may be called by the enemy's movements, which is often a matter of great difficulty. *Lastly*, We have already observed, that a prudent commander must avail himself of every good opportunity to convert a defensive into an offensive war; the various possibilities of such an event, therefore, must be anticipated, and all measures taken to make the most of such an opportunity when it occurs.

SECT. III. *Of Collecting, or Drawing the Army together.*

An army is drawn together, either for the first time, at the commencement of a war, or during a war, at the opening of a campaign, with the view of acting either offensively or defensively.

If it be intended to surprise the enemy, at the commencement of an offensive war, the troops are marched rapidly out of their quarters towards the appointed place of rendezvous. This place may be either on our own frontier, in order to penetrate, with our combined force, into the enemy's country; or in the enemy's territory itself, in which case the troops march into it at once in columns, or in divisions following each other. The first plan is generally adopted, when the enemy is not strong enough to oppose our combined force, but might annoy particular portions of the army. In other cases, the latter plan is generally preferred.

If, at the commencement of an offensive war, a surprise is impossible, the troops are drawn together gradually, for their convenience, to accustom them by degrees to the hardships of war, and to enable us to complete our measures for the campaign. It is often necessary, too, to conceal the real point of attack; and for this purpose the army is drawn together in several separate corps, which can be united at any time; or a considerable extent is given them in their quarters, in order to unite them on any part of the line at pleasure. In these measures, we must be guided very much by a skilful calculation of the distance of places, the nature of the roads between them, and the capability of the troops in performing marches.

In drawing an army together for a defensive war, we must be guided by the means we possess for conducting it, and by other peculiar circumstances. 1. If the post to be defended has been determined upon, we may then advance towards it, strengthen it, if necessary, by the labour of the troops, or of peasants, and cause it to be occupied by a detached corps; or it may be occupied by the whole army, whether the enemy's army be united or not. 2. The choice of the post depends upon the measures of the enemy. In that case we must follow his movements, and keep our quarters as much extended as is consistent with the possibility of concentrating, whenever the enemy's motions render it necessary, and with the safety of the army. If the defence of the country depends upon fortresses, the army may be drawn together in the following manner:

1. A post is chosen, from which the investment of each fortress may be prevented, or from whence, at least, it may be succoured. In this case, however, it is necessary that the army be in a condition to cope with that of the enemy. 2. The army may be divided into several corps, occupying strong camps under the cannon of the fortresses, in order to prevent the enemy from besieging them. In such a case, the cavalry is frequently formed into a separate corps, and endeavour, by constant enterprises, to put every kind of obstacle in the way of the enemy.

But if the defence depends upon a river, or other defile, a central post is generally chosen and occupied, from which the passage may always be opposed; or, if there be no such post, the movements of the enemy must be accurately observed and followed, from the first approach of the quarters, until the entire junction of the army; or separate corps are drawn together in front of the defile, which must always be able to unite sooner than the enemy, or at least to maintain their ground until they receive assistance; and which must be occasionally reinforced, in proportion to the means employed by the enemy.

The same rule may be applied to the drawing together of an army at the opening of a new campaign. It must be observed, that the attacking party is generally the first to collect his army: while the party acting on the defensive must almost always wait to see the enemy's object before he can do any thing. On some occasions, however, the latter party may be the first to collect his army; if, for example, he wishes to consume the provisions in a district before the enemy comes into the field, in order to frustrate the enterprise he may have in view; or when he is going to perform some work necessary for his defence, which must be covered by the army. In drawing an army together, attention must be paid to the season of the year, and also to the comfort of the troops, who ought not to be exposed to great hardships, until they have become habituated to active service.

Sect. IV. *Of Lines of Operation.*

Modern writers on the art of war have denominated the chain of magazines established at the commencement of a campaign, the *Basis of military operations;* and the roads by which an army receives its supplies from the magazines, are called *Lines of operation.* The situation of the principal magazine, and the length and direction of the lines of operation, are considered of the highest importance.

Single lines of operation are preferable to double ones, especially when the latter have an eccentric direction, which exposes the different parts of an army to be attacked and beaten in detail. It is always of advantage, therefore, to give to our own operations an interior direction, and, if possible, to induce the enemy to adopt exterior lines of operation. If it be necessary to form two interior lines, in order to oppose two lines of operation of the enemy, we ought not to separate them too far; because the army acting upon that which is weakest, might be attacked and beaten, with such effect as no advantage obtained on the other line could compensate. For a similar reason, a double line ought not to be presented against a single line, nor an extended line against one that is concentrated. In forming lines of operation, the chief object to be attended to is, the facility of conjunction and simultaneous co-operation. Lines of operation ought to be direct,—consequently such as will enable our troops to march with greater rapidity towards any point that is in danger, than those of the enemy, and thus to present a mass to isolated parts.

A twofold line of operations may be considered good, when the enemy shall likewise have formed a double line; provided the parts of his line have an exterior direction, while yours have an interior one; and his divisions being at greater distances than your own, cannot unite without being previously attacked by yours in mass. An army possessing lines of operation more contracted than those of the enemy can, by strategical movements, overpower the enemy's divisions successively, by alternately collecting the mass of its forces, and attacking them one after another. In order to insure the success of these movements, it will be necessary to leave a small division to oppose that of the enemy, which it is intended to keep in check; with orders not to engage, but to use every art to arrest or suspend its advance, by defending the defiles, heights, and rivers; and lastly, to fall back towards the army.* Hence it follows, that a twofold line of operations, embracing the extremities of a more contracted line, will inevitably be ruined, if the army, acting on the shorter space, know how to profit by the advantage of its situation, and the rapidity with which it can act within its own line. A twofold line of operations, opposed to a single one, will be exposed to still greater danger, if its parts are several days' march asunder, because the difficulty will then be much greater of uniting to resist any concentrated effort of the enemy. All interior and single lines of operations, therefore, will be the most secure. They offer no advantage to the enemy, but, on the contrary, should he have the imprudence to adopt a contrary system, are calculated to bring their whole mass into action against his isolated divisions.

Two interior lines of operation, possessing the means of reciprocally sustaining each other, and destined to face, at a certain distance, two exterior lines of an enemy, must avoid being encompassed by him within a space so contracted as to enable his divisions to act simultaneously; and they must equally avoid the opposite extreme,—that of pushing their operations too far asunder,—because the enemy would have time to crush that division which has been weakened to reinforce the other, and might then make such progress and conquests as might become irresistible.

Let us suppose an army, equal in force to its opponent, but acting in two or three isolated corps, upon lines of operation having an exterior direction, while the enemy operates in a body upon a single line; the army so divided will never gain any real advantage, unless the several corps can attack simultaneously; because the enemy will always have it in his power to oppose double or triple the number of troops to each of their separate corps. Hence, two interior lines are advantageous, because they can concentrate their forces at will, and with greater rapidity than the enemy, and consequently double their numerical strength. For the same reason, single lines, such as have their parts united, and can mutually sustain each other, are to be preferred.†

From these observations we may deduce the gene-

* The wars of Frederick of Prussia afford numerous illustrations of this principle. Bonaparte, too, almost constantly manœuvred in this manner, and with almost invariable success. He practised it at the battles of Quatre Bras, Ligny, and Waterloo; but failed, partly in consequence of bad calculations, and partly from the activity, skill and courage of his adversaries.

† Had the French Directory been aware of this fundamental combination, and appreciated its importance, their armies of the Rhine, the Sambre, and the Meuse, would not have been expelled from Germany in 1796, because they would not have formed a twofold line of operations acting in exterior directions. The armies of the Danube and of the [illegible] would likewise not have been sacrificed in 1799 to an erroneous plan of combinations. Had Wurmser reflected on the sublime lessons of Frederick, he would not have divided his army by a lake, and thus occasioned the defeat of each corps in detail; nor scattered his forces to cover every thing, while the enemy made the

ral principle upon which all combinations in war ought to be constructed. This principle consists in congregating upon the most important point of a line of operations, or of a field of battle, a number of forces superior to that of the enemy. To effect this on lines of operation, marches and strategical movements must be employed; and on fields of battle, we must adopt proper manœuvres, or select judicious modes of attack.

As the principles we have just laid down respecting lines of operation are also applicable to the manœuvres on a field of battle, we shall have occasion to illustrate them still farther in a subsequent section. Meanwhile, we shall only observe that lines of operations have their keys as well as fields of battle; upon these lines there are decisive strategical points, which command the remainder, and have the same influence on operations, as certain points of ground have on battles.

Sect. V. *Of Positions.*

We have already had occasion to lay down some general rules on the subject of positions, while treating of the principles of castrametation. A camp, however, may be in itself exceedingly strong, and yet totally useless with respect to the object in view. The science of positions, on the other hand, exhibits the principles applicable to the choice of a camp the best adapted, according to circumstances, to the proposed object.

In the case of an offensive war, combined with a surprise, there is no great difficulty in chusing positions. An attack in these circumstances presupposes superiority, and all the art, therefore, which is necessary, consists in the ordinary precautions for the safety and supply of the troops, which are determined by the dispositions of the enemy; and with respect to positions, there is almost nothing farther required, than the art of selecting the best routes.

But the art of positions becomes much more difficult and important, when we have to act offensively against an enemy who is fully prepared. It is then necessary to determine the best means by which we may be enabled to break into his parallel. 1. If this is to be effected by a battle, the art of positions is of less importance; because, in that case, we must attack him in the position which he has chosen; or, if it be too strong, we must endeavour to force him out of it by skilful manœuvres. 2. If it is to be done by cutting off his forage and supplies, we must establish ourselves in a strong position, near the enemy—if possible, quite on his flank, but, at all events, somewhat obliquely, in order that our light troops may get into his rear, and intercept his convoys. No pains should be spared in procuring intelligence respecting his foraging parties, which must be constantly annoyed by all possible means. At the same time, we must beware of exposing our own parallel, which should always be secured by fortresses, or posts, or detached corps. Or we should endeavour to out-flank him in his position, by occupying tenable places, or positions for separate corps on his flanks, to enable us to get into his rear, and attack all his convoys and foraging parties. 3. If our purpose is to be executed by means of detachments, we must previously observe upon what grounds the effect of a detachment rests. So long as our main army remains on the spot, it is presumed that the enemy cannot move; for otherwise the position must have been ill chosen. A corps is then detached from the army, as strong as is required and can be spared, in order to execute some enterprise injurious to the enemy. This enterprise may consist either in a particular blow, such as the attack of a post, the cutting off a convoy, the destruction of a magazine, &c.; or in preparation for some blow, which is to be executed afterwards by the whole army; such as the investment of a fortress, throwing bridges over a river which the army is to pass, occupying the entrance and *debouche* of a defile, &c. It is not always necessary that the corps should actually execute the enterprise, but only that it should be so placed as to be able to execute it, if the enemy takes no measures to oppose it.

The following general rules are to be observed, with respect to the position of the main army and its detached corps. 1. The main army must never weaken itself so much by detachments, as to be under any apprehensions for its own safety. 2. No corps must be detached in such a way as to be exposed to danger. 3. In sending out detachments, we must always provide for the junction of the whole army on the necessary point, to secure its safety, or to execute the proposed enterprise, or any other that may offer. Besides, the position of every detached corps must be chosen, so as to enable it to execute an enterprise dangerous to the enemy, and at the same time, if opposed, to have the means of executing some other.

In a defensive war, the art of positions is of the greatest consequence. 1. A position may be chosen which covers the whole parallel. Such a position must be strong in itself; the enemy must not be able to get round it at all, or only with his whole army, and that not without exposing his own parallel or communications. 2. The position may cover the greater part of the parallel. Such a position, besides being strong, must have obstacles on both sides, which, although they do not reach to the end of the parallel, force the enemy to make a large circuit to get round, while he can be opposed by a much shorter movement. 3. The position may be such that the parallel can be covered only by manœuvres. This may be done in three ways. In the first place, a central position is chosen for the whole army, from which the object of every movement made by the enemy may be frustrated by a shorter movement. In the second place, we may follow the enemy in all his movements, always choosing positions of proper strength, and so near to him, that, from fear of being himself attacked, he can undertake nothing, unless with his combined force. In these circumstances, we must endeavour to beat, or at least annoy, all his convoys, foraging parties, and detachments. Thirdly, we may extend our line in proportion as he extends his. When he makes a movement in his parallel, we

decisive march upon Trent and Bassano. Had Alvinzi, Cobourg, the Prince of Lorrain, and Brown, not mistaken these precepts, and operated without combination, they would not have been beaten in detail. Looking to still more recent events, we find that the same causes have uniformly produced the same effects. The governments have constantly caused their armies to act on the same erroneous drinciples, and the results were accordingly such as might have been anticipated. Thus, Mack was isolated at Ulm; the movements at Austerlitz were too extensive; the three corps of Prussians, at Jena, Weimar, and Auerstadt, were without connection; Buxhovden and Benningsen were not united at Pultusk; the Austrians were divided at Abendsburgh, Eckmuhl, and Ratisbon. These instances afford most convincing proofs of the truth and importance of the above observations.

make a corresponding one in ours; when he detaches a corps, we do the same, always calculating the time it will require to join the main body, in order that we may always be in a situation to unite more rapidly than the enemy. Should he expose a detachment, a communication, or magazine, we must endeavour to take advantage of the opportunity, and to change the relative situation of the war. We must beware, however, of committing any such fault ourselves, and that is a matter of great difficulty; for as the enemy begins all movements, and we must regulate all ours by his, it is scarcely possible to avoid some dangerous exposure. Hence, this method is the most hazardous of all.

An army with both flanks secure against the possibility of being turned, is in a most advantageous post; but where defensive measures are to be literally followed, such positions will seldom occur. It is more easy to gain a flank in an open country, it is more decisive where there are mountains; because, in mountainous ground, the enemy may be hemmed in, and cut off from its magazines. These are, indeed, manœuvres of a delicate nature, which require to be conducted by a general possessed of more than ordinary abilities, and commanding an excellent army. With these advantages, the assailant certainly has the best chances of success, provided he is sufficiently cautious in chusing positions which do not expose his own communications to a counter operation on his flank or rear, by which the enemy might force him to fight on disadvantageous terms. No corps whatever must be posted in a valley, unless we are masters of the mountains which form it; and if we cannot occupy both sides, we must at least occupy one; for though, at first sight, mountains, rocks, and woods, may appear impassable, yet, upon a diligent inquiry, the contrary will be always found; for in every country that is well peopled, there are, and must be, communications between the villages, at least for infantry. We ought, therefore, to occupy the mountains and woods with our infantry, and the valley beneath with our cavalry, which will hinder any enemy from passing through it.

The conduct of a defensive war is always a matter of great difficulty. In defending a province, it is necessary that our movements in every direction along its frontiers may be made with facility; or, that a position be selected, which the enemy cannot attack with the prospect of success, nor turn without being exposed to be cut off from his own magazines and line of operations; in short, a position from which he cannot force us to retreat. Posts of this description, however, are rarely to be found; for if the enemy be active, resolute, fertile in resources, and possessed of an army well versed in manœuvres, he will constantly find means to penetrate, at least with infantry, and turn our flanks. The attempt to cover every town and village will always be found impracticable. The perfection of defensive war consists in preventing an enemy from obtaining any advantages, which may enable him to accomplish his main object. When, therefore, the precautions are so carefully taken, that at the end of the campaign he finds himself no nearer the attainment of this object than he was at the beginning, then a defensive war has been properly conducted, notwithstanding any other advantages or acquisitions of territory he may have obtained.

There is in every camp some one essential point, or hinge, which may be called the key of it; and on which the strength of it most immediately depends; while you keep this, the enemy has nothing, and when you lose it, all is lost. The same holds good as to positions. The choice of this point, with regard to positions, depends entirely on, and must be regulated by, the object which the general has in view; by the situation of his magazines, and by the number and species of his troops, that he may not only have a good position, but likewise a good field of battle, in case he is attacked. On the talent of discovering these points, depends the science of camps and positions, and the method of attacking and defending them.*

We may conclude this branch of the subject with the general observation, that no position, however strong, can secure an army remaining immoveable within it from being overwhelmed, or turned at one or other of its extremities; and that the only certain method to prevent such a misfortune is by manœuvring in the same sense as the enemy, that is offensively, and by threatening his own line.

Sect. VI. *Of Movements.*

An army ought never to make a movement without having some object in view, and measures should always be taken to secure that object with as much safety and convenience as possible. A movement may be made forwards, or towards the enemy; to the rear, or from the enemy; aside, in our own, or, at the same time, into the enemy's parallel: and the object of all these movements may be, to give battle; to avoid a battle; to change our camp for the better maintenance of the troops; to prevent such a design in the enemy; to entice him into some other quarter, or prevent him from establishing himself there; for the purpose of passing a river or defile, or of preventing the enemy from passing it; to invest a fortress, or prevent the enemy from investing one; with the view of making a feigned march, in order to deceive him, and then to attain our object by another movement.

In every movement, two things are especially requisite to enable us to attain our object. In the first place, celerity; and, secondly, good arrangements. Celerity is of two kinds; it consists either in the rapidity of the movement itself, or in its continuance. Both are called forced marches. Cavalry perform a forced march in the one way, and infantry in the other. But as both are destructive to men and horses, they ought never to be undertaken without urgent necessity; and a skilful general will not often be obliged to have recourse to them. The arrangements consist, first, in lightening the army, by removing all heavy carriages that can be dispensed with; secondly, in preparing the roads; and, thirdly, in the occupying of posts, and sending out detachments, in order to facilitate or secure the march.

A movement is rendered secure, 1 By concealing it from the enemy; which may be done by breaking up suddenly, by marching at night, by avoiding every thing that can betray the march, such as drawing in the posts, extinguishing the fires, striking the tents, &c. or by de-

* These decisive points are neither numerous nor difficult to discover. On a scattered line, we must look for them in the centre, from whence one of the extremities is overpowered—as at Prague, Marengo, Austerlitz. On a contiguous line, they are on the extremity of that flank which has most connection with the general basis of the operations—as at Leuthen, Castiglione, Ulm, and Wagram.

ceiving the enemy with illusory appearances, such as smoke, dust, &c. 2. By providing against every accident. For this purpose, the ordinary dispositions for a march, which we formerly noticed, are to be observed; and we may calculate in what points of the march we can take up positions, and how much time will be required to place the troops in order of battle in every point; posts and detachments may be sent out, in order to obtain early intelligence of the enemy's motions, that we may have time to form in order of battle in every such position. We may cover the march by occupying the passes through which the enemy could reach us, or such objects, under the fire of which the enemy would be obliged to pass, should he wish to attack the army in march; or we may place cavalry in such a situation as would enable them to fall upon the flank of the enemy on his approach. For the convenience of the march, it is necessary that we have good roads, and make no circuits, nor expose the troops to any unnecessary fatigues.

We shall afterwards have occasion to treat of the march forwards, for the purpose of giving battle, as well as of the movements in passing and defending defiles. In marching to the rear, in order to avoid a battle, we must pay particular attention to our own situation and circumstances, and to the probable enterprises of the enemy. If he be quite close to us, and can immediately attack us, we must take every possible precaution to conceal our march, and to perform it in safety, especially if we have a discouraged army. All the heavy artillery and baggage must be sent to a distance before us; the march must be performed rapidly, but without disorder; and we must endeavour, before the enemy can attack us, to gain some defiles into which he cannot follow us. If he be at such a distance from us, that he cannot follow us with his whole army, but only harass us with a corps of cavalry and dragoons; in that case we may, according to circumstances, diminish the hardship and fatigue which the troops would otherwise have to undergo.

The other kinds of movements are such as are made with a view to the attainment of some particular object, or to prevent the enemy from executing some design. In marching with a view to attain some particular object, we must take especial care that our own parallel remains covered, and for this purpose three things must be observed. 1. That our communications be not cut off. This rule, however, may be overlooked, as long as the army carries a sufficient supply of necessaries along with it, or finds those necessaries at the place of its destination. 2. That the enemy do not carry any place, or destroy any of our magazines. 3. That the enemy be not in a situation to prevent us from returning, if necessary, into our own parallel, a thing which might easily happen, if he were to take up a strong position between the army and our own territory.

When sufficient precautions have been taken, with respect to the points above mentioned, movements of this kind may be made in a three-fold manner: 1 With the whole army. 2. With divisions at the same time, which is called a combined movement, and is often employed in marching towards the enemy, with the view of giving battle, or to force a defile, or invest a town. 3 With divisions following each other. In every movement, two things are to be apprehended,—an attack while on the march, and an anticipation on the part of the enemy. We have already spoken of the dispositions which ought to be adopted, with a view to prevent our being attacked while on the march, or to render such an attack harmless; and we shall have occasion to revert to the same subject in a subsequent part of this article. To prevent the enemy from anticipating us, it is necessary that we should keep our design concealed; that our movement should be made with celerity; and that previous arrangements should be made for removing all obstacles which might obstruct or detain the army, as well as for enabling it to accomplish the march, and attain its object with safety. Secrecy, indeed, is not always consistent with these previous arrangements; and it will require much skill and knowledge of the country to combine both in as great a degree as possible Favourable circumstances, too, are requisite to enable us to secure the means of success by previous arrangements; but it may sometimes be done by occupying some place or post with a detachment, or some defile which the enemy must pass, in order to prevent the object of our movement. In this case, it is necessary that the place or post which we have occupied, or the defile, be so situated as to prevent the enemy from occupying the position which he means to take up; and then all the rules which we formerly laid down, with respect to detachments, must be observed.

A combined movement is one, in which the divisions of the army march without being able to form one contiguous order of battle. It is often employed, because it enables us to execute the movement with greater rapidity; it has the effect of diverting the attention of the enemy; and it gives us an opportunity to make an attack in more places than one, either upon the whole of the enemy's army, or on some large corps, or to hem in some of his troops. In such operations, it is necessary that all the divisions of the army should be secure during the march; and this may be the case, 1. When we are certain that the enemy is ignorant of our movement, either because it has been kept completely concealed, or because all the passes have been secured, so that we can obtain immediate intelligence of all his motions on any of the marching divisions. 2. When every division has a route which secures its retreat, in case of the enemy's approach. 3. When each division is always certain of finding positions on its march, which will enable it to maintain itself until others come to its assistance. 4. When the enemy, in attacking one of our divisions, would be certain of being himself attacked by another on his flank, before he could beat the first.

The march by divisions following each other is adopted, when great defiles prevent the march of the whole army; when one part of the army, which can move with greater rapidity, is previously dispatched in order to secure the means of performing the march with the whole army; or, when we have not wholly determined upon performing the movement, but wish to have a start. In the first case, there must be no chance of the divisions being exposed to an attack, either in the defile itself, or in the *debouche* from it. In the second case, the division in advance must either be able to maintain its ground until the army comes to its assistance, or to make its retreat without any disadvantage to itself or the rest of the army. To which we may add, with regard to the third case, that the dispatching the division in advance must not interfere with, far less render impossible, any other movement of the army, which may be afterwards found necessary.

In order to prevent the enemy from attaining his object by any movement, we may remain obstinately in our position, if it be such as gives us an opportunity of inflicting such injury upon him as must necessarily detain him; or we may move ourselves to the place of his destination, or to an opposite quarter, either with the whole or a part of the army. We should march with the whole army towards the place of the enemy's destination, when we know for certain that he will, or that he must move to that point; or that we should risk a great deal by suffering him to accomplish his object, but would be in no danger should he afterwards relinquish it, and even make some other movement. In this case, the army must be prepared for battle, if it should not be thought preferable merely to encamp opposite to that of the enemy, with a defile between. We should march with a part of the army towards the enemy's point of destination, either when the enemy himself employs only a part of his force, or when a part of the army is sufficient to frustrate the enemy's design; for example, when the object is to prevent the passage of a defile, which a part of the army can defend against the whole force of the enemy; or, in case of the investment of a fortress, where the mere reinforcement of the garrison with one or two thousand men is frequently sufficient to frustrate the whole enterprise.

We may move with the whole army in an opposite direction, 1. When we are certain of being able to inflict upon the enemy a blow, which will be of more consequence than any advantage which he could derive from his movement. 2. When we are equally certain that the apprehension of the blow which we may strike will compel him to abandon his design. We may employ only a part of the army in such a movement, if a part be sufficient to inflict the intended blow; if it be necessary that we should be prepared, after executing the blow, to move in the direction which the enemy has taken; if we be uncertain whether the enemy may not abandon his design, from apprehension of the blow which we threaten; or if, by withdrawing the whole army from the position which it occupies, we should expose ourselves to danger.

Feigned marches are such as are made, not for the purpose of accomplishing our real design, but in order to induce the enemy to make some movements, which shall enable us more effectually to attain our object. These may also be performed, either with the whole or a part of the army. The design with which we blind the enemy, must be a probable one, and such as he may easily take for our true object. The more probable the better; and best of all, when it may be converted into the true one. When such a movement is made with the whole army, we must take care that it do not lead us too far from our real object, much less give the enemy an opportunity of rendering it entirely abortive. For this reason, the movement is frequently performed slowly, the army is extended, and the advanced guard, especially the light troops, spread far out in front. The movement is generally performed by dispatching a division of the army towards that side on which the feint is made, with a number of light troops to conceal its real strength. And should the enemy follow this division, we may then move with the rest of the army, or a part of it, towards the true object. In this case, it will be of advantage if it be not necessary for the detached corps to form a junction with us before we commence our movement; but that we begin at once, and at the same time, send an order for its return. Meanwhile, false reports with respect to our designs may be circulated, but in such a way as may induce the enemy to believe them to be true. The corps which is detached for the purpose of executing the feigned movement must, of course, be under no apprehensions for its own safety.

An army, weak in numbers, cannot make detachments while near a superior enemy; because they may be cut off, and beaten in detail. With a small army, it should be a maxim to act constantly in a body; for it cannot attempt to form any enterprises but by the observance of this rule. The system of covering every point must be abandoned, and our endeavours solely confined to the preservation of that object, which eventually must determine the success of the campaign. If, for example, the enemy should detach a corps to operate a diversion, capture a magazine, or undertake a siege, opportunities may arise of attacking him with a force otherwise far inferior. Should he be defeated, his detachment must likewise retreat, and his whole project is rendered abortive. A small army is also sometimes enabled to fall upon these detachments before they can retire, or be sustained by the main army.*

SECT. VII. *Of the Passage of Rivers and other Defiles, and the Means of Defending them.*

Every place where is is necessary to march with a very small front, including, of course, bridges, is called a defile. It is necessary to distinguish the entrance, the defile itself, and the outlet, or *debouche*. Now, as troops, so long as they are in the defile, are in a defenceless state; and if one part be on one side, and the rest on the other, neither can come speedily to the assistance of the other; the passage of a defile is difficult, and easily opposed. Defiles, therefore, have always been of great importance in war.

There are two descriptions of cases in which the passage of a defile is attended with difficulty. 1. When the enemy is posted on the other side, and we wish to march towards him. 2. When we are on the same side with the enemy, and our object is to place the defile between him and ourselves. In the first case, the enemy may either be aware of the point at which we wish to pass, and be prepared to dispute the passage; or he may be in doubt with respect to the point, and we endeavour to pass unperceived. It must be observed, that a defile cannot be said to be passed, until the whole troops are through it, or, at least, until so many are placed, and in such order, on the opposite side, that the enemy cannot prevent the passage of the whole.

In the case of most defiles, the roads are already prepared. But rivers have generally this peculiarity, that the passage must first be prepared by throwing a bridge over them, which is commonly a bridge of boats or pontoons. But, in order to enable us to throw over those bridges, and to defend them, it is necessary to have a body of troops on the other side. And as, in almost all cases, the fire of our artillery, and sometimes even of our small arms, can reach the opposite

* Prince Henry of Prussia gave two examples of this kind in one year (1759,) by defeating General Vehla at Hoyerswerda, and General Gemmingen at Dommitch. Two such prosperous events often give the superority to a weaker army, and compel a stronger antagonist to act with great circumspection.

side, and thus cover the construction of the bridge, the passage, and the deploying of the troops, a river may often be passed, but any other defile seldom, by force.

In order to effect the passage of a river by force, it is necessary,—1. That we should have a convenient situation for constructing more than one bridge; and hence the bank should neither be too high nor too low. 2. That we should have an advantageous position for the artillery, and also, if possible, for the small arms, so that they may have a cross fire at the place where the bridges are constructed. The heights, therefore, on the side from which we are to cross, must be more elevated than those on the opposite side; at the place where the bridges are formed, the river should have a bend inwards; and the river itself should not be too broad. 3. That there be no new defiles on the other side of the river, but a good free space where the troops can easily form under their fire, and then proceed to attack the enemy.

The following dispositions are then made for the passage. 1. The artillery and troops are stationed at those points where they can act with most effect upon the opposite side, and, if possible, they should be placed behind breast-works. 2. Troops are sent over, partly for the purpose of constructing the bridge, and partly in order to throw up entrenchments before it, which must be the more strongly constructed and occupied, the less we can depend upon the effect of the fire from our own side for protecting the entrenchment, the bridge, and the deploying of the troops on the opposite side. These troops must get over by means of fords, boats, or rafts. In fording, the cavalry generally cross over, carrying the infantry behind them. The cavalry remain on the opposite side, if they have nothing to apprehend from the enemy's fire, and, under the fire of their own people, keep themselves ready to attack all that approach the entrenchment or the bridge itself. As soon as the bridge, and the works on the opposite side are completed, the troops commence the passage, in such order as circumstances require, rapidly, but without too much haste. The order depends upon the nature of the ground. If the country be level, and favourable for cavalry manœuvres, the horse must pass first, in order to cover the passage of the infantry. If it be necessary to occupy an advantageous position with artillery, a corps of infantry, with a brigade of the park, takes the lead. The situation may be so favourable for the passage, that the troops, as soon as they arrive on the other side, can deploy and march forwards; it frequently happens, however, that they must first place themselves in the entrenchment, and gradually advance and deploy as they receive reinforcements. 4. When the enemy perceives that the passage is certain, he generally retires. If he does not, as soon as the requisite number of troops arrive, he must be attacked according to the nature of the ground and of his position; and he must be beaten, otherwise we should be in a most perilous situation; and therefore such a passage must never be attempted without a moral certainty of being able to accomplish it.

In order to effect the passage of a river by stratagem, it is necessary, 1. To choose a position from whence we can speedily reach several places where a passage may be accomplished; and in such a manner, that when the enemy places himself so as to oppose us at some of these points, he will be obliged to make a circuit before he can reach the others. 2. To make all kinds of feigned dispositions, and feigned movements, with the whole or a part of the army, in order to mislead him. 3. Should he expose any part, we must endeavour to send over a corps of cavalry and infantry, with the articles necessary for forming an entrenchment, at such places where they can best effect a passage. 4. These must construct bridges, and entrench themselves as rapidly as possible, and, at the same time, occupy, as far as their force will permit, those places from which the debouche can be covered. 5. If these measures succeed, the army prepares for the passage, and the support of the corps. 6. When the dispositions have been so far completed, the army passes, after having previously occupied all those points, which can cover and secure the passage and the debouche. 7. As the troops arrive, they must be so placed as to protect the passage of the rest, and to secure all the further advantages. 8. Should the enemy, notwithstanding, still attempt to dispute the passage, our movements must depend upon circumstances. If we are too weak to drive him back, we must stop and observe his motions, and make our dispositions accordingly, either to continue the passage, should he neglect the proper opportunity, or to secure a safe retreat for those who have already passed. In the latter case, the enterprise has failed, and we must attempt it in some other manner. But if we are strong enough to bid defiance to the enemy, we must either prepare to receive his attack, if our position be a strong one which covers the passage; or if the passage cannot be completed without driving back the enemy, we must attack him without hesitation, with the troops which have got over, before he is aware.

In the case of other defiles, the dispositions are much the same, only that, in general, we have no occasion to be detained in preparing roads. Almost every thing, therefore, must depend upon our having secured the debouche; which must be done by throwing forward a corps to take possession of some tenable place, or good position, at the outlet of the defile. If this has been effected, we have gained every thing. But the longer the defile, and the more difficult the roads through it, the less easy will it be to effect this object. Hence, the passage of this description of defiles is considered as much more difficult than that of rivers; especially if the enemy has fortified the passes, because these must first be forced, and then the debouche secured.

In opposing the passage of a river, it is presupposed that the enemy can find no points at which he can effect the passage by force, or, at least, that he has not the superiority necessary to enable him to accomplish that object. The following are the general dispositions for preventing the passage of a river. 1. We must break down all the bridges in the neighbourhood, and destroy all the fords, and secure all the boats and vessels above and below, as far as we can reach. Should any bridge be left standing, it must be sufficiently secured by a strong entrenchment, or *tete-de-pont*. 2. We must occupy all those posts from whence we can obtain intelligence of the enemy's movements, and at the same time obstruct his passage. 3. If we have sufficient time and means, we should throw up entrenchments at all important points which command the passage, in order to occupy them as soon as we learn that the enemy intends to pass at that place. These entrenchments must be so situated, that if the enemy had suddenly occupied them, we should still be able to drive him out. After these preparatory dispositions, we may adopt one of two plans. In the first place, we may take a position on the river, opposite to the enemy, and follow all his motions with the whole or a part of the army, in order to oppose his passage at every point. Or, secondly, we may take a position with the whole army, not quite close to the river, but at a distance to be determined by its course, which will enable us to arrive at any point where the enemy might attempt to pass, before he can accomplish his object. The country on and about the river must be strongly occupied with posts, in order to obtain early intelligence of every one of the enemy's motions. As soon as we are assured that the enemy is seriously attempting the passage at any particular point, we must march thither, and attack all that have already crossed, or destroy the bridges, or at least prevent him from persevering in the enterprise, if we can do nothing more. We must beware, however, of allowing ourselves to be drawn too rapidly to any one point, as the enemy might then really effect the passage at some other place. So long as we are in a state of uncertainty, we should merely hold ourselves in readiness to march, or send a corps in advance, for the purpose of obstructing the operations of the enemy. The advantage of this method of defending a river consists in this, that the army is not separated in consequence of the passage of the enemy, nor receives any serious blow, nor is forced to expose a great part of its parallel, in order to unite at a great distance behind. There is still a third method of defending the passage of a river, but which can only be employed by an army which is nearly equal to that of the enemy, when the course of the river does not admit of our adopting the second method, in consequence of the river presenting a convex bend to the defending party. This method is, to pass the river ourselves, to take up a strong position close to the enemy, and then hold ourselves in readiness to beat him while he is engaged in the passage. Bold as this method may appear, there is no doubt that it may be attended with singular success under proper precautions. In all enterprises of this nature, indeed, especially where troops can only be brought successively into action, much will always depend upon activity, boldness, and decision; and the fortunate issue will generally be determined by the first attack. When the leading columns have crossed a bridge, or penetrated through a defile, and have maintained their ground until the army is come up and enabled to support them, the success of the event is determined. Hence, it is always of essential importance to prevent the deployment of the leading columns; not a moment must be lost in charging them; the least hesitation may produce irretrievable ruin. The attack being resolved upon, it must be made with impetuosity, because, should it be repulsed, there can be little hope of making a second more successful.

The defence of all other defiles may also be conducted according to all the three methods above described: and the two first always depend upon preventing the *debouche*. But in the case of these other defiles, another method still remains; which is, to establish ourselves within them, by means of fortresses or redoubts. If such posts cannot be turned, or when placed on hills, if they are not commanded by higher eminences, they render the passage of the defile impossible. In establishing such posts, therefore, we must have these circumstances particularly in view, and also to keep the road itself completely under their fire.

The passage of a river or other defile, with the view of placing it between us and the enemy, is, on this account, a matter of difficulty, because there is a period at which the army is divided, and the enemy can attack it at the greatest possible advantage. In such a case, we may either conceal our intention, or we must effect it in the face of the enemy. The following are the general rules applicable to both cases. 1. All the baggage, heavy artillery, and all the carriages that can be dispensed with, should be sent far before us, to some secure place. 2. A strong position should be taken close to the river; and the more close, if we can conceal the time only, and not the place where the passage is to be effected; but, at all events, in such a manner that we may be able to march upon several points of it. 3. Behind this position, bridges should be thrown, shortly before the march, and secretly, if we wish to conceal the place; but otherwise, at the most convenient points, and without any attempt to conceal our intentions. 4. If there be positions on the opposite bank of the river which can cover the passage, they should be occupied with troops and artillery, and strengthened, if necessary, by redoubts. 5. The passage should be made in a continued and orderly manner, but without hurry, until all have passed, except the detachment which is destined to break down the bridges, and which must afterwards pass over in boats. 6. In case of being attacked by the enemy, we must make a proper use of all the means of defence which we have prepared, without engaging with him farther than is necessary to secure the passage. Besides, we must endeavour, in the first case, to seize the first favourable moment to effect the passage, and, if possible, to deceive the enemy by fallacious movements, with respect to the real point. When this cannot be done, we should endeavour to conceal the time, by breaking up during the night, or in the midst of a thick fog, a storm, &c. and employing all kinds of warlike stratagems. Notwithstanding all these precautions, we must not neglect to take every measure for securing the passage against accidents. The rear guard must occupy all the posts that can cover and protect it, and all must be prepared to assist it, in case of necessity.

When it is not possible to conceal from the enemy either the place or the time of the passage, and he has it in his power to attack us at any time, it will be necessary to adopt the additional precaution of entrenching ourselves in several lines, so that when the army has beeen weakened by the passage of a part, the rest may not have too extensive a line of defence. Nothing should be neglected that can tend to conceal the retreat. In the case of other defiles besides rivers, there is little difference in the dispositions, except that the precautions employed to cover the passage at the opposite side are unnecessary, and all our attention, therefore, must be turned to the rear guard, which can only be slowly succoured.

It is unnecessary for us to say any thing of the means of passing a defile, when the enemy is master of both sides, and the army, in attempting the passage, must cut its way through; because this is quite a desperate situation, out of which it is almost impossible to extricate ourselves, and into which no general can fall, without gross errors and incapacity. In such a case, we should have to contend with the twofold difficulties of a retreat, and the forcible passage of a defile. Success in such a case must be ascribed to good fortune, and not to good conduct.

In order to prevent the retreat through a defile, it is necessary, 1. That we should be vigilant, to prevent the enemy from effecting the passage secretly. 2. That we have an accurate knowledge of the enemy's situation, that we may regulate our project of attack accordingly, and carry it into execution before he has time to effect his object; for which purpose we must drive him as close to the river as possible, in order that he may not be able to conceal from us the point where he means to pass. 3. That we should make such dispositions as will enable us to make an attack every moment, especially during the night, by keeping the troops, cavalry, infantry, and artillery, constantly in readiness.

Sect. VIII. *Of Battles.*

A combat between two entire armies is called a battle; when a part only of the one army is engaged with a part of the other, it is called an action. It is not necessary for us, however, to make any such distinction here, as the disposition and arrangements for both are the same, and the number of the combatants makes the whole difference. We shall only observe, that one is more easily induced to risk an action than a battle, because the former is not so decisive.

In this section, we propose to consider the reasons which should induce us to give or refuse battle; the arrangements for battle, including the order of march and disposition of the troops; the different modes of attack and defence, and the consequences of victory and defeat.

It is a general rule, that we should never give battle, unless when we have no other means of attaining our object; or when we have much to gain, and little to lose by it. The following are some of the principal reasons which should induce us to give battle. 1. To relieve some important place. 2. To enable us to besiege some important place belonging to the enemy. 3. To cover a seige which has been already commenced. 4. To drive the enemy out of a country, or, 5. To defend a country against him. 6. To deprive the enemy of an ally; or, 7. To induce an alliance with others. 8. When the army is on the point of getting into an awkward situation, from which it can only be saved by a successful battle. 9. If we foresee, that if we do not give battle now, a period will come, in which we shall be compelled to do it under much more unfavourable circumstances. 10. When we perceive, from the situation of the enemy, or from some errors which he has committed, that we have it in our power to beat him.

To avoid a battle is to place ourselves in such a situation as to make it impossible, or at least very dangerous for the enemy to attack us. We act in this manner, 1. When it is more probable that we shall lose than that we shall gain the battle. For instance, if our troops are not in a good state of discipline; if we are posted on ground which is not adapted to the kind of troops of which our army consists; if we are weaker than the enemy, or if the enemy has taken a very strong position. 2. If we foresee a future opportunity of giving battle in more favourable circumstances; as, for example, when we expect a reinforcement ourselves, or that the enemy's force will be diminished; or that the enemy will be obliged to take up a bad position. 3. If, in general, we can expect less advantage from gaining the battle, than we should suffer injury by losing it; as, when the enemy's fortresses are in a better state of defence than our own; when every step which he makes in advance is laborious and expensive, while a successful battle would lay every thing open to him; when his retreat is easy, while ours is dangerous; or when, by a defeat, we should be deprived of our resources, while the enemy would still retain his. 4. In all cases where we can attain our object without a battle.

When we have resolved upon a battle, we must endeavour to give it under the most favourable circumstances. For example, when the enemy are inferior to us; when his troops are discouraged, and in bad order; when his generals are not agreed, or when we have an understanding with one of them; when the enemy is placed in a bad position, or when he is ill encamped or entrenched in a position which is otherwise good; when he is ill provided against an unexpected attack, whether in his camp, or on the march; or when his retreat is difficult, and ours easy.

When an army is desirous of giving battle, it advances towards the other in order to attack it; but if it wishes to avoid a battle, it selects a position, which must be the stronger, the more reason it has to avoid an engagement, and there awaits the attack of the enemy. It is possible, however, that both parties may be equally desirous of giving battle, and therefore advance, and attack each other wherever they meet; or, the army that wishes a battle may await the attack. In the latter case, the army takes a strong position, from which the enemy must expel it, without being able to do so without a battle.

In a battle there are three things to be considered, each of them in a double relation, viz. to the attacking and defending party. These are, the arrangements for battle, the battle itself, and the pursuit and retreat.

Among the arrangements for a battle some are common to both parties; some are peculiar to the attacking, and some to the defending party. The following are those which are common to both parties. 1. Every disposition must be made to render a victory as profitable as possible, and to diminish, as much as we can, the evil consequences of a defeat. 2. The arms must be accurately inspected. 3. We must have a sufficient supply of ammunition, and take care that it be not wanting at any place where it may be necessary. 4. We must get rid of all the baggage. 5. We must endeavour by all means to inspire the troops with courage and confidence. 6. The troops must be previously allowed to take sufficient rest and food. 7. We must have a sufficient supply of medicines, bandages, and surgeons.

The arrangements to be made by the attacking party must be regulated, in a great degree, according to the measures adopted by the defending army; we shall therefore speak of the latter first. 1. A good field of battle must be chosen, where we are to await the enemy's attack. The field must be adapted to the number and description of our troops; besides presenting obstacles to the assailants, it should afford us the means of following up a victory; it should admit of such manœuvres, as, in case of our being compelled to retire, will prevent a total and ruinous defeat; and, at all events, it should afford us the means of a safe retreat. For this reason, positions with strong projecting angles, or with defiles, especially a river, in the rear, must be carefully avoided, because the loss of a battle in such situations must be absolutely ruinous. 2 Having chosen our field of battle, we must endeavour to make the best use of the advantages which it affords; our cavalry and infantry must be posted in such situations where they can best act, and mutually support each other; the artillery, in particular, must be placed so as to produce the most decisive effect. 3. All the posts in front, which are calculated to obstruct or break the attack of the enemy, or cover a flank, should he attempt to turn our position, (such as houses, villages, heights, &c.) must be rendered as strong as possible, and occupied by the proper description of troops, in order to produce the expected advantage, and to present a powerful resistance to the enemy's attack. The possession of villages, in front, provided they are at a proper distance to be sustained, is one of the most advantageous circumstances that can occur in a field of battle; but all the advantages are lost and turn against you, if you do not sustain them. Villages, when situated as above described, and properly occupied and sustained, are so very advantageous, that a general will seldom chuse to attack them, but will rather mask them, and set them on fire with howitzers, and chuse some other point of attack, which, though in appearance less proper, will, generally speaking, succeed better.* 4. All the generals must be well instructed with regard to the nature of the position, especially that part of it, the defence of which is committed to them, and also with regard to their conduct in every event that can be anticipated, and how they are to give and receive assistance. These, again, must give similar instructions to the officers under their command.

The attacking army endeavours to obtain, by all means, the most accurate knowledge of the dispositions of the enemy. If his position be found very advantageous, we must endeavour to entice him from it, or cause him to weaken himself by detachments. For the art of a general, when he is desirous of giving battle, consists in enticing the enemy to ground where he can fight with advantage; but, at the same time, he must take care not to lose in manœuvring, the proper moment of attack. If the ground be determined upon, the army marches to it in several columns; the general being commonly with the advanced guard, for the purpose of reconnoitring the position and arrangements of the enemy. This position may be of a fourfold nature. 1. The front of the position may present no advantages to any part, and may be attacked along its whole extent. This is the case in large plains, and such ground, therefore, is sought by two armies, who are desirous of coming to a decisive action. 2. There may be an obstacle before the front, which must first be surmounted. 3. The position may be such that we can only attack certain parts of the front. 4. The enemy may be placed behind entrenchments.

In a case where it is in our power to attack the whole of the enemy's front, those who are skilled in military science notice several modes of attack, or orders of battle. 1. To attack the whole of the enemy's front with the whole of our own. 2. To throw forward one of our wings, with the view of attacking the opposite wing of the enemy. 3. To throw forward both wings, in order to attack both of the enemy's wings, and keep back the centre. 4. To advance the centre, and keep back the wings. The first is very rarely employed with our large armies in modern times, and can only take place with small corps. It is never advisable, unless we chuse to place every thing at hazard. The second is universally acknowledged to be the best mode of attack, because it enables us to concentrate our force upon the point of attack; and, by employing it, we risk less in case of a retreat, because the army can easily be covered by the refused wing. The third mode is only employed when we wish to outflank the enemy; or, when our wings consist of cavalry, who commence the attack by overwhelming every thing opposed to them, in order to fall upon the flanks of the enemy. The fourth mode is bad, because every projecting angle in a position is a weak point, and in this mode there would be two such angles. It can only be employed, therefore, when we have to attack the enemy under circumstances in which we are apprehensive of being outflanked, if the wings should leave their leaning points; for example, if, on passing a river, we were obliged to drive off the enemy, without permitting the wings to leave the *appui* of the river. All attacks, in which parts of the army advance, and others remain behind, thus forming an oblique line, are best made, on the part of the infantry, *en echelon;* the cavalry, on the other hand, rush out of the line, and make a separate attack, supported by the infantry. But we shall have occasion, by and by, to explain more particularly the various orders of attack.

If it be necessary, before proceeding to the attack, to make ourselves masters of some obstacle in front, we must examine wherein the obstacle consists; whether we cannot get round it, or how we can rapidly surmount it. Such obstacles may be of two kinds; 1. Such as from their nature obstruct the approach. 2. Such as are occupied with troops, and, by the fire from them,

* We have a fine example of this given by the celebrated Marlborough, at the famous battle of Hochstead or Blenheim. His Lordship had attacked several times the village of Oberklaw, but was each time repulsed with great loss. He afterwards, very judiciously, having left a body of infantry to mask the villages, advanced, and broke the enemy's line, and thus gained the battle. The French had garnished all the villages before their front, particularly Oberklaw and Blenheim, with a prodigious quantity of infantry, expecting that the generals of the allies would attack them, and by no means presume to advance and leave them behind; but they were disappointed, and beaten, with the loss of all their infantry posted in the villages.

Hence Jomini lays down the following rules respecting positions of this description. 1. That an army, posted behind villages, must protect its front by occupying them. 2. That for this purpose, some battalions of infantry, furnished with artillery, must be employed. 3. That the army must be drawn up at a convenient distance in rear, so as to sustain and be sustained by them; and preserve the means of withdrawing the troops, in case the enemy should threaten to cut them off, by successful movements in another point. 4. That from the danger of being turned in such posts, and the nature of their defence, only a moderate quantity of infantry is required; and that too much importance ought not to be attached to their preservation.

These ideas are justified by the event of several battles, and in particular by that above named. Had the French generals withdrawn the greater part of their infantry from Blenheim and Oberklaw, when they perceived that their line was threatened upon another point, they might have brought them to act upon the flank of the assailants, and probably have gained the victory. Admitting they had still been defeated, they would not have lost twenty battalions prisoners in these villages.

prevent the attack, because we should be compelled to present a flank to them; such as villages, heights, &c. If the obstacles are of the first kind, we must endeavour 1. To force the enemy to leave his position, by a rapid movement towards his flank or rear, by which means we may be enabled to avoid or surmount the obstacle; 2. If that be impossible, we should endeavour to discover some place, which, either from the nature of the ground, or the want of prudence on the part of the enemy, is not exposed to his fire; 3. We should examine whether, from some point, we may not be able to bring a superior fire to bear upon him, and thus silence his fire at those points where our passage is obstructed. At all events, our troops must be supplied with all that is necessary for forming a road over the obstacle; indeed more than one road should be prepared, and the breaking off and deploying ought to be performed in good order, and with rapidity. In the case of obstacles of the second kind, we should, 1. Endeavour, by an oblique attack on the flank or rear of the enemy, to relieve ourselves from the necessity of attacking the obstacle itself; 2. If that be not practicable, we must endeavour to pave a way for ourselves by artillery; in which case, howitzers, used against villages and entrenchments, will be of great service; 3. We must make an attack upon them, according to the nature of the circumstances, supported by the whole army.

If we can only get at the enemy at certain points, where we are sure that he has concentrated his whole force, we must endeavour to ascertain the number, situation, and nature of these points; whether some of them may not have been neglected, and which of them have the weakest fire; whether we may not be able to draw off his attention from some of them, by false attacks or otherwise; or whether, by means of batteries well placed, we may not be able to silence his fire on the points of attack. Our dispositions must be made accordingly, and we must determine the number of attacks, and the time at which each is to be made; the number of troops to be employed, with the order in which they are to attack, as well as the position of the troops which are to sustain each attack; as also, what is to be done after a successful or unsuccessful attack, and how a false attack, which has made good progress, may be sustained.

The following dispositions are necessary in the attack of an entrenched camp. In the first place, we must examine the whole entrenchment, in order to find out its weak parts. These may have been occasioned by the fault of the enemy; as, for example, when the flanks are not secured; when, at some points, the works are not complete, of a weak profile, or are so constructed, that we can approach them without being exposed to their fire; or the weakness may be occasioned by the nature of the ground. It is also necessary to ascertain the means which the enemy possesses within his entrenchments, to renew the contest, or to make a good retreat. In the second place, having sufficiently investigated these matters, we proceed to make our dispositions for the attack. These consist, 1. In determining the number of attacks, false and real, with the time at which they are to be made; the number of the troops, their order, &c. as above. 2. The troops must be supplied with all things necessary for the accomplishment of their purpose, such as hurdles or fascines, if there are wolf-holes,* or marshy places to be passed, or ditches to be filled up, and axes, when pallisades, &c. are to be attacked. 3. We must determine the signals, and the time of the several attacks. With regard to the latter, we may observe, that night attacks have the following advantages: We can the more easily surprise and alarm the enemy; while we conceal our own dispositions, and have little or nothing to apprehend from his fire until we come up to the entrenchment. But this mode of attack has likewise great disadvantages: the columns may easily lose their way, and miss the time and place of attack; we must dread the most dangerous kind of defence, by the enemy mounting the breast-work, and preventing us from climbing up. The troops cannot be kept together at night; many remain behind; and terror and disorder spread as easily among the assailants as among the defenders. In a night attack we lose the advantage which might be expected from a previous cannonade on the enemy's works; and even if we should succeed in penetrating the works, it is probable that we may not be able to follow up our advantage, and to render it decisive. On account of these disadvantages, most attacks on entrenchments are made by day. In general, we would recommend the following rules as the safest with respect to the time of attack. A night attack should be made only when we expect to take the enemy by surprise; or when he has bad, discouraged, or ill-disposed troops. It is always advisable, however, to march, and make our dispositions during the night, in order to commence the attack by day-light, unless we have reason to dread confusion and disorder. At all events, we should attack as soon after dawn as possible, in order that we may have time to follow up a victory.

Hitherto we have taken it for granted that the defending party had made good dispositions. It is possible, however, that he may have committed errors, which must also be taken into the account. The troops may be ill posted or disposed upon the field of battle; the troops, or the different kinds of arms, may not be able to sustain each other; the reserves may be ill placed, or at too great a distance; a part of the line may form a projecting angle, perhaps not very well covered; we may be able, by a rapid movement, to compel the enemy to change his order of battle; or, he may be, as it were, nailed to his position, from the fear of losing some essential advantages by attempting to advance.

When in this way all the necessary dispositions for the attack have been made, the following general rules are to be observed: 1. The army, which had previously been marching in columns, is placed in order of battle, generally by deploying. This manœuvre must not be performed at too great a distance, in order that the army may not have occasion to break off again, while marching to the attack; nor too near, lest it should be performed under a dangerous fire. 2. The artillery is moved up to those points required by the plan of attack. 3. At the proper time, the command or signal for the attack is given, and the troops immediately march upon the enemy.

In case we are to attack the whole of the enemy's

* Round holes, generally about two feet in diameter at the top, one at the bottom, and near two deep, with a sharp pointed stake driven into the bottom.

front, we proceed in the following manner: 1. The army is commonly drawn up in two lines, with the necessary reserves, and in complete order of battle, if the ground admit of it, otherwise the intervals are extended, but never beyond the half order, which must not be exceeded. 2. The army then move forwards, according to the pre-determined mode of attack, either under the fire of the artillery, or after the latter has done the expected execution, taking care not to break the line. 3. The nature of the ground, and other circumstances, must determine whether the attack is to be made first with cavalry or infantry, or with both at once; and whether troops of one kind are to be opposed to troops of the same or a different description. But whatever is to be done must be done resolutely. 4. If we have thrown the troops opposed to us into disorder, we must immediately form and prepare to receive or to attack the second line or reserve. 5. If there be no second line or reserve, or if these also have been beaten, the victors should not give themselves entirely up to the pursuit, but send a detachment for that purpose, sufficient to prevent the enemy from forming again; while the rest endeavour to improve the advantages obtained, by falling on the enemy's flank, or taking such a position as will cut off his retreat. 6. The artillery must fire upon those batteries which most annoy the troops in their advance, or upon the points chosen for the commencement of the attack.

If there be some obstacle in front which must be previously surmounted, the cannon must play upon it, while the troops destined to attack it, march upon it in column at those points where they are least exposed to the enemy's fire. The rest of the artillery endeavour partly to interrupt the communication between the enemy's army and the posts, and partly to secure the debouche, and to silence the batteries which would prevent it. The whole strength of a position frequently consists in such a post in front, and the enemy retire as soon as it is forced; but if they do not, the whole line must be formed, as rapidly as possible, for the attack, as soon as we have got possession of the post, in order to profit by the disorder which the flight of the troops which have been driven out of it may have occasioned in the enemy's army.

If we can attack the enemy only at certain points, we must ascertain the best method of making the attack, whether by the fire or the bayonets of the infantry, or with cavalry. If by means of fire, we should endeavour to unite as much fire as possible, both from great and small arms, on the points of attack; and the troops and cannon should be so placed as to have a cross fire. But if the attack is to be made with the bayonet, our troops in column must approach the enemy cautiously, in order that they may not suffer much from the enemy's artillery, and then attack with vigour. The cavalry must attack with that fury in which the force of their charge consists. When our fire, which, if possible, should always take place during the advance of the troops, has made an impression upon the enemy, the troops nearest them, or those who receive orders, must immediately push forwards, and avail themselves of his confusion, to make a rapid charge with the view of penetrating his line. Those who have succeeded must follow up their success, and overthrow all that advances to sustain the broken line. The troops that follow those who made the attack must fall on the flank of that part of the enemy which has not given way, and form front in order to oppose any attempt that may be made by the second line, or the reserve, to restore the combat. If we have completely succeeded in establishing ourselves on those points of the enemy's line, he retires from the field. Our more advanced troops then endeavour to occupy positions for the purpose of cutting off the retreat; the others who were engaged in the attacks, endeavour to unite as rapidly as possible, to form in line, and to support the troops engaged in the pursuit.

In the attack of an entrenched camp, the troops must be made acquainted with the obstacles which they have to encounter in each attack, and be supplied with the means of surmounting them. As many of these obstacles as possible should be previously removed by the artillery. The troops which are destined to form the attacks then march in open columns to the points of attack, and endeavour to avail themselves of all the advantages of the ground, to avoid the enemy's fire. The troops destined to support the attacks follow at a moderate distance in front. The columns should not be too strong, nor consist of more than two battalions. It were better to make several attacks than to form too deep columns. To arrive in front of the entrenchment—to spring into the ditches and climb up, must be the work of a moment. While the foremost are thus engaged, those following them must, if necessary, keep the breast-work clear by means of their fire. As soon as a part have surmounted the breast-work, the rest must immediately follow, place themselves on the top of the breast-work, drive off every thing with their fire, and even turn the enemy's cannon against himself. Under cover of this fire, the workmen clear the entrances in the neighbourhood, or make new ones, if necessary, to admit the troops. If cavalry are employed, (which is always the case when the ground will admit of it,) they charge such of the enemy as attempt to make a stand, as soon as a few squadrons are formed. If infantry, they always endeavour to gain more and more ground, and to drive off the enemy with their fire, until he leaves the entrenchment entirely, when the different attacks can unite and form line. In all attacks, it is of advantage to conceal from the enemy the true points at which they are to be made; and for this purpose all possible feints and stratagems should be employed that are consistent with the attainment of our main object.

The party acting on the defensive must first take care that his flanks be secure, and his front strong and well covered. He should then endeavour to discover the point or points against which the enemy's attack is directed; and when he perceives that a reinforced attack is intended, he must strengthen that point in such a manner as the nature of the ground, and of the troops employed by the enemy, require. All the artillery that can be brought to bear upon them must play upon the enemy's columns, and particularly endeavour to harass them while deploying. If the enemy make the attack with infantry, he must be opposed by a strong fire along the whole way to the attack, which, when properly executed, should compel him to turn to the right about. If with cavalry, they must either be charged by our own horse, or opposed by infantry; and, in the latter case, we should endeavour to manage matters so, that the cavalry, while in full charge, shall present the flank to a corps of infantry posted near them, whose fire may easily bring them into disorder. Otherwise, infantry must await such an attack without firing, until the enemy come within twenty paces, when a well-timed general charge will certainly drive back the cavalry. Our own sustaining cavalry must then break through the intervals, and convert the disorder occasioned by the fire of the infantry into a complete flight. If the enemy, while marching to the attack, should give us an opportunity of attacking him in flank, it should by no means be neglected; for in this way an attack can frequently be effectually and decisively repulsed. But, in such a case, we must take good care not to expose our own flank.

When we have beaten back a part of the assailants, we must not pursue them too keenly, but only endeavour to prevent the beaten troops from forming again, which may be done by means of light horse, or detached troops. If the enemy, on the other hand, has penetrated any part of our line, the troops appointed to sustain it must immediately come up, and endeavour to profit by the confusion which is occasioned even by a successful attack. The beaten troops must hasten to form again, and attack the enemy. If we can fall upon his flanks, we shall the more certainly force him to retire. It is very easy to apply these general rules to the particular cases.

Before leaving this subject, it may be proper to explain more minutely than we have hitherto done, the mechanism of the different orders of battle; a perfect knowledge of which is of the very first importance in military science.

All the seven orders of battle which tactical writers, since the days of Vegetius, have described, may be reduced to these two—the *parallel* and the *oblique*. The order is said to be parallel, when our front is developed in a direction parallel to that of the enemy, and can engage along its whole extent. This is the most simple and natural disposition, and must have been generally adopted in the infancy of military science. As knowledge increased, armies superior in numbers would endeavour to avail themselves of their superiority by turning the enemy's flanks; hence the disposition in form of a crescent, which is still practised in the Turkish and Asiatic armies. On the other hand, skilful generals, at the head of inferior armies, would endeavour to discover the means of compensating the disadvantage of inferior numbers by a more perfect system of tactics. They would perceive that, by presenting a front parallel to a superior enemy, they exposed themselves to be surrounded and beaten; and they would consequently be led to adopt some other disposition, some science of movements, by means of which they could bring a part of their forces to bear upon some point of the enemy's line, while the rest were kept back out of the reach of the enemy. Hence the oblique order of battle; the advantages of which were at length found to be so great, that it was generally adopted by all armies, whether superior or inferior in numbers, to the utter exclusion of the parallel formation. The advantages of the oblique order are, that since its introduction war has become a science of judicious combinations, instead of a game of chance; and that, as it does not admit of a general engagement along the whole line, the result of battles depends upon the ability of the commanders more than upon the quantity of blood that is shed. This order of battle was well known, and very celebrated among the ancients; but the King of Prussia was the first commander, in modern times, who executed it upon scientific principles, and adapted it to modern tactics.

In the oblique order of battle, it is not necessary that the front should precisely describe an oblique line with respect to the enemy's front; for it seldom happens that the nature of the ground, and other circumstances, will admit of such a perfectly regular formation. Every disposition, then, may be called oblique, in which we bring a part of our forces to act against the enemy, while the rest of the troops are kept out of his reach; every disposition, in short, in which we attack, with superior numbers, one or more points of the enemy's line, while the rest of our troops are placed beyond the reach of being attacked by him. The advantage of this order of battle consists in this, that, by attacking some part of the enemy's line with superior numbers, we are enabled to penetrate and overwhelm it, to fall upon his flank and rear, and thus force him to retire from the field.

From the nature of the oblique order, the attack must be directed against one of the enemy's wings. The main object to be attained by its means is to make an impression on the point assailed, to continue to outflank it, and to turn its rear. To render these results practicable, it is necessary to reinforce the attacking wing, so as to give it a decided superiority over the enemy; and to prevent him from reinforcing the point about to be attacked, the assailant must have recourse to every delusive art to mask his real design, until the onset is actually commenced. Then the attack must proceed with vigour and rapidity; no time must be suffered to elapse which might allow the enemy an opportunity to recollect himself. The onset must be as furious as it is unexpected, and he must be overthrown, even before he has had leisure to fire a shot.

In operating thus with a concentrated effort upon one of the extremities of the enemy's line, measures, as we have already hinted, must be taken to make this attack practicable, by masking the preparatory movements; for, without this precaution, it would be in the power of the hostile army to move in a corresponding direction with the columns intending to turn its flank, and to continue to present a front to them, or even to turn their own flanks. Hence it is necessary to conceal the march of the columns by the obscurity of the night, the conformation of the ground, or by a false attack upon the enemy's front. The two last methods are to be preferred, especially if they can be employed both together, because movements by night are more liable to uncertainty and irregularity than those made by day. In order to alarm a greater extent of front, it may be preferable to act with a corps of light troops, distributed in platoons, rather than with a continued line in the shape of an advanced guard. This skirmishing force might, according to circumstances, be augmented to six or eight battalions; and a point should be indicated to them upon which they are finally to close, and where they will be sustained by cavalry and light artillery. This method has the twofold advantage of perplexing the enemy, in regard to the real importance of the false attacks, and the number of troops employed in them; and also of attracting the attention, and keeping in check the greater part of his front, while the columns are marching to their destination.

The oblique order may be executed either in line, or *en echelon*. When formed in line, the disposition presents an oblique front in a half quarter of conversion, (Plate CCCLXXXIII. Fig. 39.) When formed by *echelons*, each battalion and squadron is out-flanked on the side where the attack is made by the battalion or squadron next it, to the extent of a certain number of paces, more or less considerable, according to the number of troops of which each column is composed, and the degree of obliquity required in our disposition. All that part of the army, however, which is destined for the attack, forms a sort of hammer in front, placed in the common order, (Fig. 40.) This disposition by *echelons*, instead of being formed by battalion and squadron, may be taken by regiment or brigade, and even by more considerable corps; these corps being placed by *echelons* at some distance from each other, so as to be able to support each other mutually when necessary, and to occupy the positions which can best prevent their being exposed to an attack, and enable them to deceive the enemy. Of these two modes of forming the oblique order, in line, or by *echelons*, the first is merely elementary and methodical. It may be well to practise it in camps of instruction, in order to make the officers acquainted with the nature and object of the oblique order. The second mode, which is derived from the first, is more simple, easier in its deployment, more applicable to all sorts of ground, and more susceptible of manœuvre and action when the disposition is formed. There are various ways of forming these oblique dispositions, which the reader will find described by Guibert and other tactical writers. Meanwhile, we shall notice another species of the oblique order, in which the army, although not drawn up obliquely in front of the enemy, places itself, either from the nature of the ground, or the skilfulness of its movements, in such a situation as enables it to make an attack upon one or more points, while it is itself out of reach of the enemy upon those parts of its line which it is desirous of refusing. This is the order which is most generally adopted in actual warfare, because it seldom happens that battles are fought on plains absolutely smooth and open, where, consequently, the dispositions may be made without regard to the nature of the ground, and in the regular obliquity established by principles. We are almost always compelled to abandon this regularity, in order to avail ourselves of the advantageous positions which are presented by the nature of the country, either to favour the illusion which we wish to practise upon the enemy, or to secure the weak parts of our line. Thus, the order of battle at Lissa, or Leuthen, may be called an oblique disposition, although certainly the army of the King of Prussia was not drawn up obliquely to the front of the Austrians; but he attacked with a strong body their left wing, took it in flank and overwhelmed it, while, at the same time, he availed himself of a chain of heights, opposite to their right and centre, in order to deceive them, to keep them in check, and to place in an excellent defensive position, the rest of his army, which was weakened by the reinforcements he drew to his right.

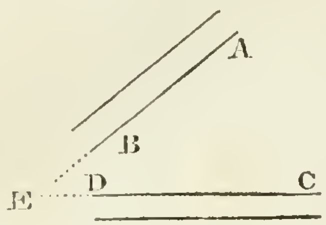
The methods of marching and fighting invented and carried into execution by the great Frederick, form an admirable study for all who would acquire a perfect knowledge of military dispositions. On examining the Prussian orders of march, at the battles of Kollin, Rossbach, and Leuthen, (Plates CCCLXXXIV. CCCLXXXV. CCCLXXXVI. and CCCLXXXVII.) it will be seen that the armies moved in columns by a flank,* each line forming a column; and that this order of march was obtained by simply breaking the lines into open columns of companies. It will be equally easy to perceive with what facility these columns again formed in order of battle, by wheeling into line. The following are the advantages which this method offers for all kinds of marches and orders of battle. 1. By means of this order of march, the army can make all its movements without being disunited; and, consequently, it is not liable to have its right or left columns successively overpowered, since the whole is formed in two only, with no more distance between them than is usual between the first and second lines. 2. The enemy cannot penetrate between these columns, or cut them off. 3. By taking the direction which the line of battle is to occupy, the army, on arriving upon the ground, can be formed in a few minutes; that is, in the time required for all the divisions to wheel into the allignement. It is only necessary to cover this march with an advanced guard, which will answer the double purpose of protecting the army, and of keeping the enemy in suspense respecting the real point of attack. 4. The army having no other distances to observe to form into two lines, than the two hundred or three hundred paces between the two columns, and that between platoons, there can be no difficulty in executing the manœuvre with precision. 5. When the army intending to outflank the enemy has reached the proper point, by a concealed movement, and is in the necessary direction for that purpose, by suddenly forming into line, the enemy will neither have time to form a *potence*, nor to change front entirely; and consequently, he will be overpowered on one of his extremities by a mass of forces which it will be impossible for him to resist. This was more clearly proved at Leuthen than in any other battle. 6 If it be not advisable to form the army into two columns, of the same length as the line of battle, they may be converted (if the ground will permit) into four, by doubling the lines, or by marching by wings, without, on that account, embarrassing the formation of the line. When the four columns moving in the order of doubled lines, have arrived within a short distance from the point where they are to form, the even columns (second and fourth) will halt, and protect the further movement of the others, until their heads are disengaged; when the first platoons will immediately fall in at a proper distance from the last of the leading columns; and thus they will be in position to wheel up, and form a contiguous line, (Plate CCCLXXXIII. Fig. 41.) If they are formed by wings, to draw up in two lines is executed by a simple change of direction, simultaneously made by the head and rear of each column. The order of march at the battle of Leuthen explains this at first sight.

To the method above described, we may attribute the facility which Frederick displayed in manœuvring upon the flanks of his enemy; and the means of keeping his army in columns until the moment of attack, when they formed line in an instant. The system of keeping his army constantly united, of opposing a mass to isolated parts, a whole line to a single extremity of a line, could only be put in execution by means of the order above described, which united promptitude of formation, with connection and simplicity.

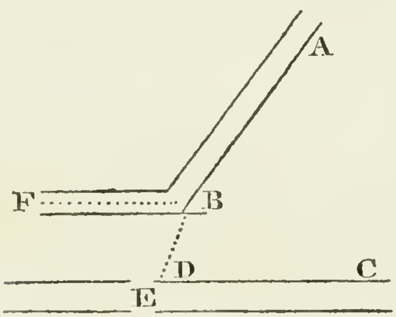
We have already observed, that in making an oblique attack upon one of the extremities of the enemy's line, measures must be taken to make this attack practicable, by masking the preparatory movements; otherwise it will be in the power of the hostile army to move in a corresponding direction with the columns intending to turn its flank, and to continue to present a front to them,

* It is not meant as a movement made in files, but a march by platoons, divisions, or companies, in column of the whole army, right or left, in front.

or even to turn their own flanks. As, for example, when two armies march in the directions CD, and AB, they will form an angle in the point E.



Whence it follows, that whichever first reaches the point E, will have gained the flank of the other, and will consequently turn it. Let AB be the army marching by divisions, or otherwise, with a strong corps of cavalry at its head, to attack and gain the flank of CD with all possible speed: if CD be vigilant, there will be no difficulty in frustrating the manœuvre, by reaching the point E before the enemy. For, having timely information, AB cannot anticipate his antagonist, because the distance from D to E is less than that from B to E; consequently CD has the advantage, and AB may be considered as defeated, provided proper care is taken to profit by the circumstance, and the attack is made boldly. To be convinced of this, we need only examine how AB can oppose it. As soon as the cavalry CD has passed the point E, the army AB has no other resource than to



form an angle or *potence* BF. This movement being executed in haste, will not be very orderly: while the cavalry in E, having already formed in line, will advance, and gain still more on the flank by continuing to incline to the left, while moving to the attack. Hence they will outflank, and make the onset before the enemy's horse in BF can be ready. Another inconvenience arises from the formation *en potence*. The army, having previously marched with proper distances between the columns or lines, is thus suddenly thrown together by the lines forming to the rear, which may produce such confusion, that both the first and second line may be routed together before they can be disengaged.

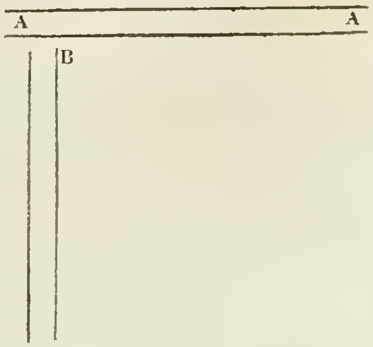
While the cavalry CD is making the attack, the infantry will have time to reach the point E; and should they be only a few battalions, they must nevertheless advance, without waiting until others are come up. Nothing would be so injurious as to lose time by irresolution, because it is evident that they can march forward without standing in need of being supported by the army; for, supposing CD to have marched by divisions to the left, and the cavalry by superior speed to have gained, during the movement, six or eight hundred paces in advance, the infantry will arrive at E, about the time that the cavalry, after having made the shock, will be engaged in forming anew, and will thus be in readiness to protect it while busied in that operation; after which they can march on both together against the enemy, who, finding his cavalry overthrown in the first charge, will be found endeavouring to form his right wing of infantry *en potence*, or with an angle thrown back; but as in this manœuvre his disordered cavalry will obstruct him, he will order them to move off to the right. If at this moment the infantry CD advance, they will find the enemy still in the act of forming, and defeat him with ease. Admitting that these battalions have preceded the others by some hundred paces, they will soon be followed by the succeeding, who, having in their turn, reached the point, will advance in a kind of *echelon* of battalions, and thus come gradually, and in proper time, into action; and if the whole take the precaution to incline towards the left, while advancing, the enemy, in a short time, will be so completely taken in flank and rear, as to make it impossible for him to take any effectual measures of resistance.* Besides, the angle at B offers an excellent mark for the artillery to enfilade and beat in reverse. In this manner a great army may be so compressed by an inferior force, as to seem totally surrounded.

The principles of the oblique attack on an enemy's flank may be farther illustrated, by considering the effects of an attack directed against an army while marching. To attack an army on the march, indeed, is advantageous, for the same reason that it is desirable to engage an extremity of an enemy's line; because the

* Jomini allows that these views, originally suggested by Tempelhoff, are sufficiently just; but adds, that he is grossly mistaken when he asserts, that two columns being brought close together, by a change in their direction, will be enfeebled, and on that account more easily defeated. Besides, it is not absolutely necessary to make this change of direction, in the case above supposed. Two brigades might be made to change front, and thus the two lines would not crowd upon each other.

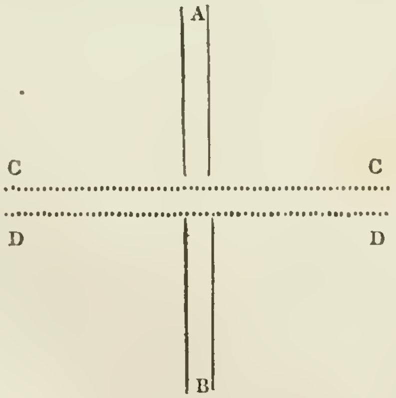
Jomini and Tempelhoff are not quite agreed with regard to the effect of an angle or *potence*, in resisting a flank attack. The latter observes, that to protect a flank by a *potence*, against an active and manœuvring enemy, is to employ a remedy more dangerous than the inconvenience intended to be avoided; and that it should never be adopted, unless the flank can be securely posted upon a point which the enemy cannot turn. Another disadvantage, he adds, attends projecting angles; namely, that the troops forming the point cannot make a retrograde movement, without crowding and causing confusion; nor can they advance, but by leaving such an opening in the position, as the troops posted to the right and left can with difficulty close; and this they can only perform by movements, which, producing a fluctuation in the whole line, are apt to cause general disorder, if attempted in the presence of the enemy. To conclude, an angle is the object upon which an experienced enemy will endeavour to accumulate a raking fire of artillery. Jomini, on the other hand, admits, that an army manœuvring with ability, will be able to turn the flank of an angle, as well as of a straight line; but he observes, that it will be necessary to make a more considerable movement; that this movement will require time, and give the enemy an opportunity to change front, and present his whole line on the point where his flank only was expected. The one, in short, will march on the arch of a circle, while the other moves on the chord; and therefore the army acting on the straight line will have completed its movement, before the other which describes the curve. Thus, while checked in front by the angle, the flank and rear will be turned by the line, and the enemy will be compelled to lose ground.

army attacked on the heads of its columns is placed, relatively to its opponent, in the same situation with that assailed in flank. This is demonstrated by the following figure.



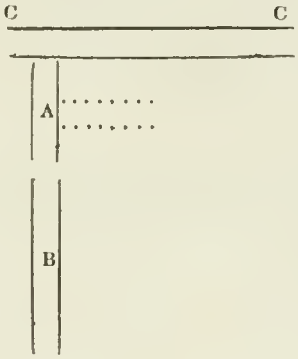
Supposing both armies in line; B will be found to be attacked by a perpendicular line, with one of its extremeties outflanked, in the same manner as the heads of its columns would be, if the army were on march.

Both manœuvres produce similar advantages; which are, that the army attacked can only bring its battalions successively into action, while the attacking force, pressing forward with vigour, is enabled to overthrow them one after another. In order to secure this result, it is not enough to attack an army on march, but the corps A must, besides, move in a corresponding direction; that is, by prolonging the march horizontally, if the advance of the hostile columns be perpendicular, and prolonging the perpendicular movement, if that of the enemy be horizontal. The object of these directions must be, to present a whole line to the head of a column, and, consequently, to a single extremity of the enemy's line. It is obvious, that if the heads of two hostile columns were to meet in similar directions, and began reciprocally to deploy, the consequence would produce a parallel order of battle, and a shock between two equal fronts, totally devoid of combinations.



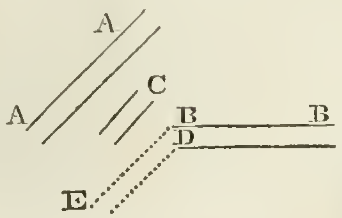
The army A, marching in two columns, is met by B, moving in a similar direction, (both perpendicularly) the first will immediately deploy, for fear of being attacked; and if the second do not instantly perform the same evolution, it will be defeated, as appears from the former figure. A, consequently, will form the line CC, B the line DD. But this reproduction of parallel fronts, of battalion opposed to battalion, unquestionably results from incapacity on the part of the commanders. The armies, thus drawn up, may destroy each other, without either gaining a decisive advantage; and whichever gains the victory, it will not be owing to the skill of the general.

An army, therefore, which is attacked on the march, will immediately endeavour to form an angle; or, in other words, the leading brigade of the columns will instantly deploy; and this deployment being either to the right or left of the columns, will constitute an angle or *potence*, as may be seen by the following figure.



A forms the advanced guard, or the head of the columns B; if it be attacked by the enemy, it will deploy to either hand, according to the direction of the attack, and occupy the dotted lines, which form an angle or *potence* with respect to the columns. This manœuvre is necessary to oppose the first efforts of the enemy C. But being secure from immediatee danger, does it follow that the army must imitate the movement of the leading brigade, and restore the parallel order? At first sight, the manœuvre appears natural, and it is most commonly the refuge of generals possessed of inferior talents; yet it is not, on that account, the most advisable. If it be proved that an attack upon a flank is most appropriate, why should not an army, of which the vanguard, or the brigade on the flank happens to be engaged with the enemy in front, endeavour in its turn to gain the flank of the assailant, and exchange defensive for offensive measures—a probable defeat for almost certain victory? Nothing can prevent a commander, when attacked in this manner, from ordering the brigade in action to defend its post inch by inch, and to retire gradually upon

A is the army attempting to turn the left flank of B, which forms the angle C; and the columns D are immediately prolonged in the direction E, by which means they turn the right flank of A. If it be objected that the enemy will not allow the manœuvre to be executed, it is answered, that to prevent it, he must either fall back or charge front. This latter movement will not be easy, in the presence of the angle, and under the momentary expectation of the columns wheeling into line.



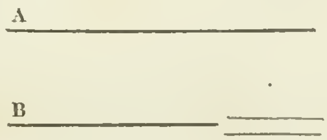
Hence are deduced the following maxims: 1. Between armies equally well versed in manœuvres, an angle may be used with success, against attacks directed upon a flank. 2. In order to make this movement without detriment, the angle or *potence* must be used only as a momentary resource; the army must follow it up by changing front, in the same direction, in order to be prepared to repulse the enemy with its whole line. 3. If the army attacked be sufficiently strong to act offensively, after forming an angle to check the enemy's front, and cover the menaced flank, it will, instead of changing front with the rest of the line, alter the direction, and march in column to a flank, so as to turn the extremity of the enemy's line in its turn. 4. An angle, with the extremity projecting to the front, does not cover the flank of the army so effectually, as when turned to the rear; for the enemy, in the former case, would readily turn the extremity of the angle, and throw it upon the line, merely by prolonging the direction of his leading divisions; while, in order to attain an angle to the rear, he would be obliged to make the circuitous march above explained.

another intermediate brigade, placed echelon-wise in its rear; and while these are engaged, he can change the direction of his columns, by facing the platoons to the right or left, and move by their flanks, until he has in his turn outflanked the enemy's line. (See Plate CCCLXXXIII. Fig. 42)

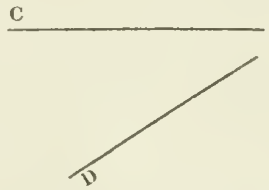
The platoons nearest the enemy will prolong their file movement considerably more than at a greater distance behind, the latter gradually taking less ground; so that the last forms the pivot, or has only to continue its original perpendicular march. From this disposition an oblique formation will result, which outflanks the enemy, and prevents his pressing forward upon the retreating brigade, because, in consequence of the new order of battle, he is in danger of being himself attacked to great disadvantage, if the enemy operates with vigour and unison. The manœuvre is both more simple and more rapid in the execution. It offers the singular advantage of placing the whole army upon an extremity of the enemy's line; while the change of front, if permitted to be performed, only restores the parallel order of battle. If this manœuvre, of an open column moving by files to a flank, appear complicated, others may be substituted in its stead, provided they are conducted on the principle of throwing the mass of the forces on the flank of the enemy.

To conclude the subject of flank attacks.

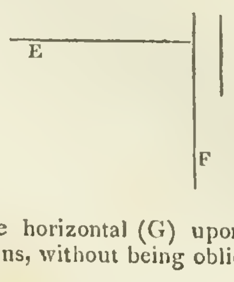
1. An army (B) may be placed out of the reach of the enemy's artillery, and consequently be ranged in a line parallel, and having one wing greatly reinforced without being oblique.



2. The line (D) may be greatly inclined, with its head towards the attack, and consequently be positively diagonal, without being reinforced.

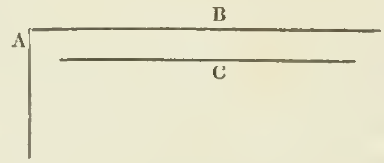


3. It may be perpendicular (F), with a wing reinforced upon the flank of the enemy, without being diagonal. Such was the disposition of the Prussians at Kunersdorf.



4. It may be horizontal (G) upon the heads of the enemy's columns, without being oblique.

There are several modifications of these different orders; as, for instance, of the third. The flank may be reinforced by an angle, or *potence*, perpendicular to the front, such as the Austrians adopted at Prague and Kollin.



The potence A, being perpendicular to the enemy's line C, reinforces the right wing of the line B, without being oblique. The same observation is applicable to an angle towards the rear.

It is probable, that the ancients, in general, preferred the parallel order, reinforced on a wing, to the oblique order. Among the moderns, Turenne employed the former at the battle of Ensheim, and the latter at Sinsheim; but these manœuvres being executed by one division only, without celerity, and in sight of the enemy, they had time to form a parallel line, and to reinforce the point attacked. The king of Prussia seems justly entitled to the honour of having first appreciated the advantages of such an order of battle as he displayed at Leuthen, because, until that moment, it had never been applied in a similar manner.

A parallel line, strongly reinforced on the most important point of attack, is unquestionably good, and coincides with the principle which we consider as the basis of all operations. It may therefore conduce to victory, but is nevertheless subjected to several inconveniences. The weak part of the line, being so near the enemy, may be drawn into action against the intentions of the commander, and be defeated, and thus frustrate the advantages which might have been gained on the opposite flank. The reinforced part of the line may defeat its opponent; but it cannot, on that account, take the enemy's line in flank and rear, without making an extensive movement, which would cause a separation from the other divisions, if they happened to be engaged. But if those divisions were not engaged, and therefore enabled to follow the movements of the reinforced part of the line, still, as this manœuvre would be circular, the enemy, by marching on the chord of the arch, would oppose to it a direct and more rapid counter-movement, which would place the offensive on his side, and bring his mass of forces first on the principal point of attack. But the disposition of the king of Prussia at Leuthen has quite a different effect; not only is the extremity of the attacked wing overpowered by a whole line, but the flank of that wing is turned, and its rear taken in reverse; and all this is performed without manœuvre, or prolonging the diagonal direction, by simply marching the whole front from its oblique position straight forward. The divisions not destined to form the first attack cannot, from their distance, be engaged with a superior enemy. They incur no such risk, and yet they are in a situation to render successively their support to the wing which is engaged.

Having thus attempted to explain the arrangements for battle, and the different modes of attack, we shall now proceed to consider what measures ought to be taken, after the termination of the battle, by the victorious, and by the defeated army. The army which has attacked and beaten its opponent should observe the following rules: 1. The light and other detached troops must instantly pursue the enemy, with the view of increasing his disorder; the whole army follows more leisurely, and in good order. 2. As soon as we can perceive the direction of the enemy's retreat, we must determine what is to be done to increase his loss; as, to cut off the retreat of a part of his force, or to place artillery in such a manner as to obstruct the retreat, and render it more confused and bloody, and prevent the enemy from rallying. 3. All the posts which have been placed for the purpose of covering the retreat, must be instantly and vigorously attacked, in order to avail ourselves of the panic among the troops. 4. We must pursue the enemy as long as day-light and the strength of the troops will permit, in order to push our victory to the utmost. For the maxim, that we ought to make a golden bridge for a flying enemy, is only to be put in practice when we can do no better. 5. As every battle is fought on account of some ulterior object, we should immediately proceed to the accomplishment of that object, as soon as we have made the necessary arrangements for the care of the wounded, &c. For every thing ought to be previously in readiness for the maintenance of the troops in their farther advance; and we must be prepared to take advantage of all the errors which the enemy may commit in his retreat.

If the victory has been gained by the army acting on the defensive, the same rules, upon the whole, are to be observed, but with more caution. For the same reasons which forced it to select a position, and there await the attack of the enemy, generally prevent it from pursuing him, and following up the victory farther. They must beware, indeed, of leaving their position too soon, and pursuing too keenly, because the enemy might otherwise turn round and attack the troops which had given up their advantages, beat and pursue them, and enter the position along with them.

If the attacking party have been beaten, the following rules are to be observed: 1. So long as there is any chance of victory, the repulsed troops must be formed again, and led on anew to the attack; or their place supplied by fresh troops; and the moment must be accurately determined, beyond which the retreat cannot be delayed without danger. 2. As soon as this moment arrives, the dispositions previously determined upon must be made. These consist in occupying with troops and artillery all tenable places, such as villages, houses, woods, heights, &c. lying at the distance of a short gun-shot from the roads along which the army is to pass, in order that the troops may securely retire under their fire. These places must be so much the stronger, if the retreating troops have a defile to pass. And, if possible, the retreat of the troops which have been thrown into them must not be allowed to be cut off, after they have accomplished their object. 3. When these dispositions have been made, the cannon are to be marched off the field of battle, in order to save our artillery. But should there be decisive batteries, which cover the retreat; we should rather sacrifice them than expose ourselves to the loss of a great number of troops: but we should also consider how the enemy can use them when he has got them. For if he cannot immediately turn them against the retreating troops, it is the less necessary to hesitate to sacrifice a few pieces of cannon to the safety of the army. 4. The troops follow the artillery; and in broken ground the cavalry march off first; on plain ground, the battalions which have been engaged in fighting fall back and march off, and the cavalry, in the mean time, take up a position, from which they can fall upon the flank of the pursuing enemy. When the infantry have thus marched off, under cover of the cavalry, the latter also retire in the best possible order. 5. A rear guard, as in every march, must be formed of those troops which have suffered least; but much stronger than upon ordinary occasions; and they must proceed with much more caution. The infantry of the rear guard occupies all that can cover the retreat; and calls in all its posts as it proceeds. The cavalry always marches in such a manner, that it can easily form in order of battle; it retires, therefore, *en echequier*, or in such other order as the nature of the ground will permit; so as to combine rapidity with order. When an obstacle occurs in a retreat, the rear guard forms in order of battle, and takes up the best position for covering the army, by which it must be supported, should it be too violently attacked.

Nearly the same rules must be observed by an army which has been attacked and beaten; only that it must commence by again forming in line, before proceeding in the retreat, at least if it is to be conducted with order. For the line of an army acting on the defensive, and beaten, is always broken; although this does not hold in the case of an army acting on the offensive. In such a retrograde movement, the points where the army is to form, and upon which it is to lean its flanks, must have been previously determined. If from this position it be possible to deprive the enemy of his advantage by a general attack, a spirited commander will not hesitate to attempt it. Otherwise the enemy must be kept in check, in the new position, until all our dispositions are made for the retreat.

Both parties, after the loss of a battle, must immediately endeavour to take up and maintain a strong position, to repair the loss they have suffered, and then proc·d again to the execution of their design. The farther we retreat, we not only lose a greater tract of country, but the army becomes more discouraged, a circumstance which is always of much greater consequence than the loss of a battle.

General Lloyd, the celebrated commentator on the military occurrences of the seven years war, has laid it down as a rule, that an army retreating ought to be divided into as many strong corps as the nature of the country will admit of; because, in this case, the enemy can do you no very essential damage. If he separates his army likewise into many corps, none of them will be strong enough to undertake any thing of consequence; and if they keep too close, they may receive some considerable check. Another advantage arising from this method of retiring is, that the enemy cannot intercept any of your corps; because he can neither push between them, nor go so far about as to come before them, without exposing his own troops to be hemmed in between your different corps. If he follows you with his whole army, one division only can be in danger; which may be easily avoided by forming a strong rear-guard, who will get time for the remainder to march off in safety; and the more so, as a small corps marches much more lightly than an army. Care must be taken not to engage the whole corps; because, if the enemy is near, and acts with vigour, it will be entirely lost.

These ideas of Lloyd, which are contrary to the principles upon which most of his own maxims are established, have been wrought up into a system by Bulow, under the title of *eccentric retreats*, in opposition to *concentric movements*. A contrary system, however, is with greater propriety, we think, maintained by Jomini. We have already observed, that an army inferior in numbers to its antagonist ought always to endeavour to act in a body; because it is only by so doing that it can hope to obtain any advantage over the enemy. It cannot be disputed, that an army compelled to retreat is already sufficiently weak, without being besides divided. All the divisions, indeed, cannot be ruined when thus separated; but one or two will certainly meet with such a fate; and the most disastrous concentric retreat cannot produce any thing more calamitous. When we shall have compared the system of Lloyd and Bulow with events, and, in particular, with the result of the concentric retreat of the Archduke Charles of Austria, in 1796, we have no doubt but the propriety of drawing opposite conclusions to their's will be universally admitted. Lloyd, indeed, is already in contradiction with himself; for he allows that the dividing of the pursuing forces exposes them to defeat. How then can he advise the pursued to commit the same fault?

Sect. IX. *Of Cantonments and Winter Quarters.*

When the weather becomes so bad that the body cannot withstand it, the troops ought not to be exposed to it in the open field, but should be placed in quarters, where they may find shelter and protection. And, as active service in the field is extremely fatiguing, they ought to be placed at the end of a campaign in extensive quarters, where they may find subsistence and comfort, in order to refresh themselves. Hence arises a twofold mode of placing troops in quarters: 1. When the only object is to shelter the troops from the weather. 2. When they are distributed in extensive quarters, with a view to their subsistence and comfort. The former are called cantonments, the latter winter quarters.

As the army is incapable of withstanding the enemy in its quarters, the general principle, whence all the rules for the distribution of the troops in quarters is derived, is this: That in case of an attack from the enemy, we should always have it in our power to draw the army together in order of battle, upon an advantageous field, before the enemy can attack us.

Rain and nightly cold force us first to place the cavalry, on account of the horses, in the villages. Their quarters must be so disposed, that the camp of the infantry completely covers them, and the enemy cannot fall upon them from behind; and that either the distance of the out-posts, or the obstacles which the ground or the resistance of the infantry presents to the enemy, should leave time for the cavalry to unite and assist in beating off the attack. The same principles must be followed, when we are compelled to place the infantry in quarters.

We place our troops in winter quarters when we perceive, 1. That we ourselves can no longer undertake any enterprise of importance; and 2. When the enemy cannot attack our troops in their quarters. The first may occur, when the capture of a fortress would be necessary to enabled us to advance farther into the enemy's country, but the badness of the weather prevents us from undertaking the siege; when no post or pass is to be carried, which would be of use in opening the following campaign, or in securing our quarters; when there are no provisions any where to be consumed, which the enemy might want; or when no blow is to be executed against his magazines, &c. The second case occurs, when our fortresses are sufficiently provided with all necessaries; or when our quarters are so disposed, that the enemy either cannot penetrate into them at all, or only with the greatest danger, or when an attack would be of no use to him, but only ruin his own army. Excepting these cases, we must wait until the enemy places his troops in quarters, and then the campaign sometimes continues during a great part of the winter.

For the security of the quarters, of whatever kind they may be, it is required, 1. In general; that the whole of the enemy's army may not be able to make an attack upon our whole quarters, without finding them prepared. 2. In particular; that the enemy's troops may not be able to attack and carry one or other of the quarters.

The general security of the quarters depends, 1. On the nature of the country between the enemy and the quarters; as when they are covered by a river, a chain of mountains, or other objects forming defiles. In such cases, we have the additional advantage, that the natural obstacles are generally still more effectual at that season of the year. 2. On the nature of the ground in the quarters, and on their situation. There must be no defiles within the quarters which can interrupt their connection; and in case the quarters should be attacked at one or more points, the troops must have the means of retiring and uniting with the army, without the risk of being cut off; which might happen, if any one part were to form a projection, not covered by tenable posts or otherwise. 3. On the measures taken to protect them. All the approaches through the defile which covers the quarters, must be destroyed or fortified. The quarters must not be too far distant from each other; and a common rendezvous must be chosen, where they can all arrive with rapidity and safety, and find an advantageous position. The proper distribution depends upon the time in which the enemy can approximate his quarters, and make an attack upon ours; for otherwise, the more they are extended, the more comfortable will it be for the troops. The rapid junction of the army on approximating the quarters, should be facilitated by improving the roads and communications, removing the obstacles, establishing signal posts, &c. The light troops in front, should constantly send out small patroles, in order to obtain notice of all that is going on among the enemy; and for the same purpose, the army should be provided with good spies.

The security of the individual quarters depends, 1. On posts being well placed on all the roads by which the enemy might approach. 2. On the judicious use of patroles towards all points from whence the enemy might approach. 3. On the good disposition of the quarters for defence against every surprise and open attack. 4. On the discipline of the troops under each commander, and the regular performance of their duty. The troops, in quarters, however, should never be unnecessarily subjected to fatigue.

There is scarcely any operation in war more delicate and difficult, than the distribution of the troops into winter quarters; it requires a perfect knowledge of the country, and must be regulated by a prodigious variety of circumstances. 1. Regard must be had to the enemy's disposition; 2. to his general plan of war, and to the particular object he has in view for the ensuing campaign; and, 3. to the object you have yourself in view for the following campaign. If you propose to be on the defensive, the distribution of the troops must be made in such a manner, as to be able to unite in different points, without leaving even a possibility of their being intercepted in their march to the place of rendezvous; that these points be chosen as near the frontiers as possible, in order to cover the country; and that they be so well chosen, that the enemy can neither force you in them, nor leave you behind. If you propose being on the offensive, the troops must be so distributed, that, in one march or two, they may form several great corps on the enemy's frontiers, and pass them, so as to separate his quarters, and run no risk of being intercepted before they join, and form one body in the enemy's country. Above all things, care must be taken that they are not exposed to be inquieted during the winter, which the troops must enjoy in peace and safety, as well to refresh themselves, as to form the recruits, &c.

The following is the manner in which the army is generally distributed in quarters: 1. The troops of the right wing are placed in the villages lying to the right, those of the left wing in the villages to the left, in the same order in which they encamp. 2. The troops of the first line are placed in the more advanced villages, those of the second in the villages lying behind, in proportion to the extent of ground occupied by the army. 3. The whole of the infantry, however, is placed in the first and second line, and the cavalry in the third; for the latter has no security in villages. 4. The light troops are placed in front and on the flanks of the army, but, if possible, so as to be in some degree covered against the enterprises of the enemy, in order that they may not be obliged to provide for their security by hard service, otherwise the chief object of the winter quarters, viz. the refreshment of the troops, of which they have so much need, would be rendered nugatory. They are, therefore, placed in front, but on this side of the defile which covers the army; from whence they may watch over the security of the army by constant patroles, consisting of only a small number of troops. This is called the *cordon* of the quarters. 5. The light infantry, or detachments of the army, occupy the entrenchments on the bridges, or other passes: but there, likewise, all proper measures must be taken for the maintenance and comfort of the troops.

The petty war which the troops carry on against each other along the *cordon*, is of little consequence; for although they endeavour to attack every individual quarter, as soon as they find that the commander has neglected any of the measures of security; yet such an attack, even if successful, would have little influence, if the quarters were otherwise well disposed; and several attacks could only succeed against useless troops. The following, therefore, are the only things worthy of attention. 1. Attacks upon a principal post in the quarters; and, 2. A general attack on the whole quarters. Both enterprises may have a strong influence on the attacking army, and therefore should not be wantonly undertaken. In the first case, we must inquire, 1. Whether the object be worth the trouble. For example: Can we compel the enemy to raise his whole quarters, and transfer them? or can we maintain the place, and does it open to us the way to further enterprises? or, finally, are we so certain of success, that the hope of making prisoners is sufficient to induce us to undertake it? 2. Is it probable that we shall succeed? This probability must result from the bad disposition of the quarters, which enables us to approach them undiscovered; from the neglect of proper measures on the part of the commander to prevent a surprise. The situation and circumstances must be such as to afford us the means of a safe retreat. When the attack has been determined upon, the same rules are to be observed as in the case of all other detachments; and we may also observe, that it is almost necessary to success, that we should get into the rear of the quarters, either with the whole or a part of the detachment; partly because the attack from thence will be more unexpected by the enemy, and therefore have a greater chance of success; and partly, because we may thus attack him on more than one side, raise his whole quarters, and cut off his retreat.

A general attack upon the whole quarters of an army is, in all points, similar to an attack on an enemy's country, in order to surprise it. The following reasons may induce us to make such an attack. 1. A bad disposition of the enemy's quarters. 2. Measures ill taken among his troops for the performance of their duty. 3. A well founded hope that we shall be able to drive the enemy out of the country in his possession, either immediately, or upon the opening of the campaign. This may be the case, if the enemy have neglected some tenable places, and left it in our power to make ourselves masters of them; or if he has enclosed some of our fortresses within his quarters, which the lateness of the season prevented him from taking, and which will serve us as *points d'appui* in our advance; or, lastly, if his whole quarters consist of an open country, from which we can drive him behind defiles, which he will afterwards in vain endeavour to pass. 4. The success of such an enterprise will be greatly promoted by a skilful disposition of our own quarters, by good and secret arrangements within them, by which we shall be enabled to draw them rapidly together, and move into those of the enemy.

Sect. X. *Fundamental Principle in Military Combinations.*

In this concluding section, we propose to lay before our readers a summary of the essential principles of military combinations, extracted from Jomini's excellent *Treatise on Military Operations.*

The fundamental principle which ought to regulate all military combinations, consists *in operating with the great mass of our forces, a combined effort on the decisive point.* We may easily conceive, that a skilful general may, with 60,000 men, beat an army of 100,000, if he can but contrive to bring 50,000 men into action upon one part of the enemy's line. The numercial superiority of the troops not engaged, in such a case, is more hurtful than advantageous, because it only tends to increase the disorder, as was proved at the battle of Leuthen. The rules for applying the principle above laid down are by no means numerous, and we shall endeavour to point them out.

I. The first rule is, to originate, or take the lead in all movements. The general who succeeds in placing this advantage on his side, has it in his power to employ his forces wherever he thinks it most advisable; on the other hand, he who waits for the enemy cannot be master of any combination, because his movements are subordinate to those of his adversary, and because he has no longer the power of arresting them when they are in full execution. The general who takes the lead, knows what he is going to do; he conceals his march, surprises and overwhelms an extremity, a weak part. He who waits, is beaten on one of those parts, even before he has been informed of the attack.

II. The second rule is to direct our movements on that weak part which can be most advantageously attacked. The choice of this part depends upon the enemy's position. The most important point is always that of which the occupation would procure the most favourable chances, and the greatest results. Such, for example, would be the positions which should enable us to gain the communications of the enemy, with the basis of his operations, and to throw him back upon an insurmountable obstacle, such as a lake, a large river without a bridge, or a great neutral power.

In double and scattered lines of operations, our attacks will be most appropriately directed on the central points. In carrying the mass of our forces to that quarter, we overwhelm the isolated divisions which guard them; the scattered corps to the right and left can no longer operate in concert, and are forced to make those ruinous eccentric retreats, from which the armies of Wurmser, of Mack, and of the Duke of Brunswick experienced such terrible effects. In simple lines of operations, and in contiguous lines of battle, the weak points, on the contrary, are the extremities of the line. Indeed, the centre is more within reach of being sustained, at the same moment, by the right and the left; while an extremity attacked would be overwhelmed before the arrival of sufficient means from the other wings to sustain it, for these means would be much more remote, and could only be employed one after the other.

A deep column, attacked on its head, is in the same situation with a line attacked on its extremity; the one and the other will be engaged and beaten successively, as has been demonstrated by the defeats of Rossbach and Auerstadt. At the same time, it is easier to make new dispositions with a column in depth, than with a line of battle attacked on an extremity.

In executing a general strategical movement on the extremity of an enemy's line of operations, we not only bring a mass into action against a weak part, but from this extremity we may easily gain the rear and the communications, either with the basis, or with the secondary lines. Thus, Bonaparte, when, in 1805, he gained Donauwerth, and the line of the Lech, had established the mass of his force on the communications of Mack with Vienna, which was the basis of this general in respect to Bohemia, and rendered it impossible for him to unite with the Russian army, which was his most important secondary line. The same operation took place in 1806, on the extreme left of the Prussians by Saalfeld and Gera. It was repeated in 1812, by the Russian army in its movements on Kaluga and Krasnoi; and again in 1813, by Bohemia on Dresden and Leipsic against the right of Bonaparte.

III. The result of the preceding truths proves, that if we ought to prefer an attack on the extremity of a line, we should also beware of attacking the two extremities at once, unless indeed our forces are greatly superior. An army of 60.000 men, which forms two corps of about 30,000 each, for the purpose of attacking the two extremities of an army equal in numbers, deprives itself of the means of striking a decisive blow, by multiplying uselessly the number of the means of resistance which the enemy can oppose to its two detachments. Such an extended and disunited movement may even expose it to the enemy, who may collect the mass of his force upon one point, and annihilate his adversary by the terrible effect of his superiority. Attacks multiplied in a greater number of columns are still more dangerous, and more contrary to the great principles of the art; especially when these columns cannot be brought into action at the same instant, and at the same point. As a consequence of this maxim, it is proper, on the contrary, to make an attack upon both extremities, when we have masses greatly superior to those of the enemy; we may thus bring more troops into action upon each of his wings, while, by keeping very superior forces accumulated upon a single point, our adversary might perhaps be able to deploy and bring into action an equal number. We must take care, in this case, to throw the great body of our force upon that wing, where the attack promises the most decisive success.

IV. In order to operate a combined effort with a great mass upon a single point, it is necessary, in strategical movements, to keep our forces collected upon a space nearly square, in order that they may be more disposable.* Large fronts are as contrary to good principles, as scattered lines, large detachments, and isolated divisions.

V. One of the most efficacious means of applying the general principle above laid down is, to make the enemy commit faults contrary to that principle. We may threaten him with some small corps of light troops on several important points of his communications; and it is probable, that not knowing the force of these corps, he may oppose them with numerous divisions, and scatter his forces. These light troops, at the same time, serve the essential purpose of collecting intelligence for the army.

VI. It is of great importance, when we originate any decisive movement, to neglect no means of informing ourselves respecting the enemy's positions, and the movements which he may make. The system of *espionnage* is very useful, and no pains should be spared to bring it to perfection; but it is still more essential to procure accurate intelligence by means of partisans. A general ought to scatter small parties in all directions, and to multiply their number with as much care as he would avoid such a system in great operations. For this purpose, some divisions of light cavalry are organized, which are not admitted into the line of battle. To operate without these precautions, is to march in the dark,

* By this is not meant a full square column, but that the battalions be disposed in such a manner as to be able to arrive, with the same promptitude, from all points, towards that which may be attacked.

and to expose ourselves to all the disastrous chances which a secret movement of the enemy might produce. We have already observed, that these partisans would contribute, at the same time, to alarm the enemy upon some important points, and thus induce him to divide his forces. These means are too much neglected; the system of *espionnage* is not sufficiently organized before hand; and the officers of the light troops have not always the experience requisite to enable them to conduct their detachments.*

VII. In conducting the operations of war, it is not enough to carry our masses skilfully on the most important points; we must also know how to bring them into action. When we have established ourselves upon these points, if we remain inactive, we have lost sight of the principle entirely. The enemy may make countermanœuvres, and to deprive him of the means of doing so, we must immediately engage him, as soon as we have gained his communications or one of his extremities. It is at that moment especially that we ought to combine a simultaneous effort of our forces. Battles are not decided by the masses present, but by the masses engaged. The former decide the preparatory strategical movements; the latter determine the success of an action. In order to obtain this result, a skilful general ought to seize the moment when it is necessary to carry the decisive position of the field of battle, and he should combine the attack in such a manner as to engage all his forces at the same time, with the sole exception of the troops destined to form the reserve. If an effort founded upon such principles shall not be successful, we cannot hope to obtain the victory from any combination, and we shall have no other resource but that of making another attempt with this reserve, in concert with the troops already engaged.

VIII. All the combinations of a battle may be reduced to three systems.

The first, which is purely defensive, consists in awaiting the enemy's attack in a strong position, without any other object than that of maintaining ourselves in it. Such were the dispositions of Daun at Torgau, and of Marsin at the lines of Turin. These two events serve to demonstrate how vicious all such dispositions are.

The second system, on the contrary, is entirely offensive. It consists in attacking the enemy wherever we can find him; as Frederick did at Leuthen and Torgau, Bonaparte at Jena and Ratisbon, and the allies at Leipsic.

The third system is in some degree a middle term between the two others. It consists in choosing a field of battle, determined according to its adaptation to strategical purposes, and the nature of the ground, in order to await the enemy's attack, and to seize, during the battle itself, the proper moment for assuming an offensive attitude, and to fall upon our adversary with every chance of success. The combinations of Bonaparte at Rivoli and Austerlitz, those of Wellington at Waterloo, and in the greater part of his defensive battles in Spain, may be classed under this head.

It would be difficult to lay down precise rules for the employment of these two last systems, which are the only ones that can be successfully adopted. We must always have a view to the moral disposition of the troops of each party, to the peculiarities of the national character, and to the nature of the ground; and these circumstances alone may direct the genius of a commander. We shall confine our remarks, therefore, to the three following general observations. 1. With experienced troops, and on open ground, the absolute offensive, the *initiative* of attack, is always the best system. 2. In ground of difficult access, whether by nature or from other causes, and with well-disciplined troops, it is perhaps better to allow the enemy to arrive in a position which we have previously reconnoitred, in order to take the lead of him when his troops shall have been exhausted by their first efforts.

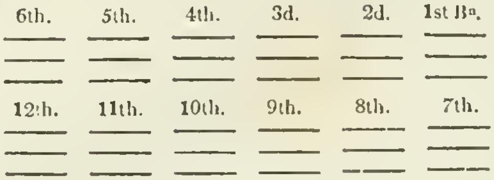
3. Nevertheless, the strategical situation of both parties may sometimes require, that we should make a lively attack upon the positions of our adversary, without regard to local circumstances; for example, if it were of consequence to prevent the junction of two hostile armies,—to fall upon a detached part of an army, or upon a corps isolated on the other side of a river, &c.

IX. The orders of battle, or the most proper dispositions for conducting troops into action, ought to have for their object to give them, at once, activity and solidity; for they ought neither to be too extended nor too crowded. A spare order is weak; troops crowded into too dense an order are in a great degree paralised, because it is only the head that can be brought into action, they are easily thrown into disorder; and artillery makes dreadful ravages amongst them. It appears to us, that in order to fulfil both conditions, troops remaining on the defensive may be partly deployed, and partly in columns by battalions, like the Russian army at the battle of Eylau; but the corps drawn up for the attack of a decisive point ought to be composed of two lines of 'battalions each, instead of deploying, being

* The immense advantages which the Russian armies derived from the services of the Cossacks, afford sufficient proof of the truth of the above observations. These light troops, insignificant in the shock of a great battle, are terrible in a pursuit. They are the most formidable enemy for all the combinations of a general, because he can never be certain of the safe arrival and execution of his orders, and his convoys are always in danger, and his operations uncertain. So long as an army had only a few regiments of these partisans, the whole of their value was not known; but when their number was increased to 15 or 20 thousand, an idea could be formed of their importance, especially in a country, the population of which was not unfavourable to them.

For one convoy which they intercept, we must cause them all to be escorted; and the escort must be numerous in order to insure safety. We are never certain of performing a march unmolested, because we know not where the enemy are. These incidental duties require an immense force; and the regular cavalry are soon rendered totally unfit for service, in consequence of the fatigues to which they are exposed. The Turkish militia produces nearly the same effect on the Russians, as the Cossacks on the other European armies; the convoys are not more secure in Bulgaria, than they were in Spain and in Poland. In other armies, perhaps, some thousands of volunteer hussars or lancers, levied at the commencement of a war, and directed by enterprising leaders, on well chosen strategical points, would accomplish nearly the same object; but we should always have to look upon them as detached and independent troops, for if they were to receive their orders from head-quarters, they would no longer be partisans. It is true, they would not possess precisely the same qualities; and, in the long run, they could not contend with good Cossacks; but, to an unavoidable evil, we must apply all the remedies in our power.

formed in columns by divisions, in the following manner:*



This order presents infinitely more solidity than a deployed line, whose fluctuations prevent the impulse necessary for such an attack, and put it out of the power of the officers to carry on their troops. At the same time, with a view to facilitate the march, to avoid the too great depth of the mass, and, on the other hand, to increase the front, without at all injuring its consistency, it would perhaps be more proper to place the infantry in two ranks. The battalions would thus be rendered more moveable; for the march of the second rank, pressed between the first and third, is always fatiguing, fluctuating, and, consequently, less firm and lively. Besides, they will have all the requisite force, as the three divisions will present six ranks in depth, which is more than sufficient. Finally; the front enlarged to the extent of a third will present more fire, if it should come to firing; and at the same time that it appeared more formidable to the enemy, by shewing him more men, it would be less exposed to the fire of artillery.

X. In ground of difficult access, such as vineyards, enclosures, gardens, and walled heights, the defensive order of battle ought to be composed of battalions deployed, and covered by numerous platoons of sharpshooters. But the attacking troop, as well as the reserve, could not be better drawn up than in columns of attack by the centre, as in the preceding observation; for the reserve must be ready to fall upon the enemy at the decisive moment, and attack with force and vivacity, that is to say, in columns.† Nevertheless, this reserve may be left partly deployed until the moment of charging, in order that the extent of its front may appear the more formidable to the enemy.

XI. In a defensive battle on open ground, we may substitute, for these columns, squares of battalions, by doubling the lines of the two ranks, so as to form them on a depth of four. Each battalion would thus present a sufficient mass, as it would have only a front of from forty to fifty files.

This order seems advantageous, when we have to fear grand attacks of cavalry; for it gives, at once, security to the infantry, and shelter to the cannoneers and to the train of artillery. At the same time, as it affords less activity and less impulse than that of columns of attack, the latter appears preferable, because, with troops well exercised, it is easy to form the square in each battalion, by a simple conversion to the right and left of the centre division. The general's plan of battle, the nature of the ground, the description of troops, must determine the preference to be given to these two orders.

XII. If the art of war consists in concerting a superior effort by a mass against weak parts, it is incontrovertibly necessary to push a beaten army vigorously.

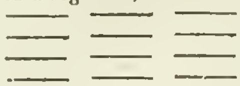
The force of an army consists in its organization, in the whole resulting from the connection of all the parts with the central point which sets them in motion. After a defeat, this whole no longer exists; the harmony between the head which combines, and the body which ought to execute, is destroyed; their relations are suspended, and almost always dissolved. The whole army is then a weak part; to attack it is to march to a certain victory. Abundant proofs of these truths will be found in the march on Roveredo, and the defiles of the Brenta, to complete the ruin of Wurmser; in the march from Ulm to Vienna,—from Jena to Wittemberg, Custrin, and Stettin,—from Waterloo to Paris. This maxim is often neglected by generals of inferior talents. It would appear that the whole effort of their genius, and the scope of their ambition, were limited to gaining the field of battle. Such a victory is a mere displacing of troops, without any real utility.

XIII. In order to render the superior shock of a mass decisive, the general must spare no pains in forming the moral disposition of his army. To what purpose should we place 50,000 men in order of battle against 20,000, if they wanted that impulse which is necessary to carry them forward, and to overwhelm the enemy? We do not allude merely to the soldier, but still more particularly to those whose business it is to lead. All troops are brave, when the chiefs shew the example of a noble emulation and perfect devotion. The soldier must not remain exposed to fire from the mere dread of a rigorous discipline; he must rush into it by the desire of not being outdone by his officers in honour and bravery, and, above all, by the confidence with which he has been inspired in the wisdom of his leaders and the courage of his companions in arms.

In all his calculations, a general must be able to reckon upon the zeal of his lieutenants; he must be assured that a vigorous attack will take place wherever

* A division consists of two platoons; thus the battalion being composed of six companies, or six platoons, will have three divisions, which, in fact, will cause it to form on three lines.

This remark, however, refers to the French constitution of battalions and regiments; but it is obvious that the idea could be easily modified so as to apply to our own, by forming our battalions into columns of four grand divisions (supposing the flank companies absent) closed to half distances, and a whole brigade, as a regiment, is formed in the above order. Thus:



Or if the ground would not admit of the depth of these columns, they might be made only of two grand divisions in rear of each other.

† It has been said that the Duke of Wellington always fought with his troops deployed. This may be true in so far as relates to the troops who were to remain on the defensive, but for his offensive and manœuvring wings, we think he must have formed columns. Otherwise, those must have been greatly to blame, who allowed themselves to be beaten, with equal forces, by such a system; for a General could desire nothing better than to have an adversary who should always employ it.

It must not be thought, however, that in presenting an order of battle as the most advantageous, we mean to assert that a victory would be impossible, unless it were strictly followed. Local circumstances, general causes, superior numbers, the moral disposition of the troops and of the commanders, are considerations which must also be taken into the account; and in reasoning from a general maxim, we must assume that all these chances are equal.

he orders it to be made. In order to attain this end, he must render himself at once beloved, esteemed, and feared; and he ought to have the choice and the fate of his lieutenants in his own hands. If they have arrived at this rank by the right of seniority alone, we may conclude beforehand that they will scarcely ever possess the qualities necessary to enable them to fulfil their important functions. This circumstance alone may cause the failure of the best planned enterprises.

It will be seen from this rapid sketch, that the science of war is composed of three general combinations, each of which presents but a small number of subdivisions. The only perfect operations will be those in which these three combinations shall be properly executed.

The first of these combinations is the art of embracing lines of operations in the most advantageous manner, or what it commonly called *the plan of a campaign*. We do not well understand, indeed, what is meant by this term; for it is impossible to lay down a general plan for a whole campaign, the first movement of which may overthrow the whole scaffolding, and in which it may be impossible to foresee beyond the second movement.

The second branch is the art of conducting our masses in the most rapid manner possible to the decisive point of the primitive or accidental line of operations. This is what we commonly understand by strategy; which is nothing else than the means of executing this second combination.

The third branch is the art of combining the simultaneous employment of our greatest mass on the most important point of a field of battle; or the art of battles, which some authors have called the order of battle, while others have treated it under the name of Tactics.

See the works of Xenophon; Arrian; Polybius; Cæsar; Vegetius; Folard; Montecuculi's *Memoires, avec les commentaires du Comte Turpin de Cressi;* Turpin, *Essai sur l'Art de la Guerre;* Puysegur, *Art de la Guerre, par principes et par règles;* Marechal de Saxe, *Lettres et Memoires*, &c. Paris 1794. The works of the King of Prussia. Lloyd's *History of the Seven Years' War*, with Tempelhoff's continuation Guichard, *Mémoires Militaires sur le Grecs et les Romains.* Warnery, *Remarques sur le Militaire des Turcs et des Russes*, Breslaw, 1771. *Ejusd, Commentaires sur les Commentaires du Comte de Turpin sur Montecuculi*, &c. St. Marino, 1777. *Ejusd. Remarques sur la Cavalrie*, 1781. *Ejusd. Mélanges de Remarques, surtout sur Cæsar*, 1782. Ejusd. *Campagnes de Frederic II.* Sir David Dundas, *Principles of Military Movements.* London, 1788. Bülow.*Geist des neuern Kriegs Systems*, Hamburgh, 1802. Guibert,*Essai général de Tactique*, Paris, 1803. Muller's *Elements of the Science of War*, London, 1811. Thomson's *Military Memoirs. Caractere Militaire des Armées Européennes*, &c. London, 1802. Rogniat, *Considerations sur l'Art de la Guerre*, and the German translation by Major Decker, under the title: *Ansichten über die Kriegführung im Geiste der Zeit* Berlin, 1817. Jomini, *Traité des Grandes Operations Militaires*, and *Histoire Critique et Militaire des Campagnes de la Revolution.* (z)

EXPLANATION OF THE PLATES.

PLATE CCCLXXXI.

Fig. 1. Represents a battalion forming Front to the Rear by a Counter-march of the whole.
Fig. 2. Forming Front to the Rear by a Counter-march of Platoons.
Fig. 3. A Battalion forming Front to the Rear by wheeling about.
Fig. 4. One half faced to the Right-about, previous to wheeling.
Fig. 5. Forming Front to the Flank, by facing to the Right or Left, and marching up.
Fig. 6. The same, by Deploying.
Fig. 7. The same, by a single quarter Wheel.
Fig. 8. The same, by an eighth Wheel, by Companies, the Flank Company only making an entire Wheel.
Fig. 9. The same, by wheeling round the Centre.
Fig. 10 & 11. Forming from Line into Columns.
Fig. 12. Forming, or Deploying, from the Centre.
Figs. 13, 14. A Battalion in Column marching off to the Right and to the Left.
Fig. 15. Marching forwards in Columns.
Fig. 16. Marching to the Rear in Columns.

PLATE CCCLXXXII.

Fig. 17. A Counter-march by Columns.
Fig. 18. Columns breaking off on a narrow road, or defile, without halting.
Fig. 19. The Oblique March by Columns.
Fig. 20. Close Columns forming Front.
Fig. 21 Deploying from the Centre.
Fig. 22. The Movements reversed, the last Division forming the Head.
Fig. 23. Forming Front to the Rear by counter-marching and deploying.
Figs. 24, 25. Close Columns forming Front to the Flank.
Figs. 26, 27, 28. Columns formed by wheeling placed in order of Battle to the Front.

PLATE CCCLXXXIII.

Figs. 29, 30, 31, 32, 33, 34, 35, 36. Columns forming Front to the Rear.
Fig. 37. Columns deploying close to a Defile.
Fig. 38. Passing Obstacles, and forming Line.
Fig. 39. The Oblique Order in Line.
Fig. 40. The Oblique Order by *Echelons*
Fig. 41. An Army, in four Columns of March, forming Line.
Fig. 42. An Army attacked on its Flank, changing the direction of its Columns, and gaining the Flank of the Enemy.

PLATE CCCLXXXIV.

Order of Battle at Kollin.

PLATE CCCLXXXV.

Order of Battle at Rossbach.

PLATE CCCLXXXVI.

Order of Battle at Leuthen.

PLATE CCCLXXXVII.

Lines of March, 1. At Kollin ; 2. At Rossbach ; 3. At Leuthen.

MILITIA. See Britain, and England.

MILK. See Dairy.

MILL. See Barley Mill, Drug Mill, and Hydrodynamics.

MILLAR, John, Professor of law in the university of Glasgow, was born on the 22d of June, 1735, in the parish of Shotts, of which his father, Mr. James Millar, was then minister. His mother was the daughter of Mr. Hamilton of Westburn, a gentleman of considerable estate in Lanarkshire. He received the rudiments of his education at the grammar-school of Hamilton; and, in 1746, he repaired to the college of Glasgow, where he formed an acquaintance with the celebrated Mr. Watt, afterwards of Birmingham, Dr. Adam Smith, and other eminent characters.

Mr. Millar was originally destined for the church, but he afterwards resolved to devote himself to the profession of the law. About the time he had finished his studies at Glasgow, he received an invitation from Lord Kames to reside in his family, and superintend the education of his son. In this situation he continued about two years; during which period he had an opportunity of cultivating the acquaintance of Mr. Hume, the historian, and was entrusted with the education of his nephew, the present very eminent professor of Scotch law in the university of Edinburgh.

In 1760, Mr. Millar was called to the bar; and he was soon looked upon as a very rising young lawyer. Circumstances, however, soon afterwards induced him to abandon his prospects at the bar, and to solicit the vacant appointment of professor of law in the university of Glasgow, which he obtained in 1761. About the same time, he married Miss Craig, a lady nearly of his own age, to whom he had formed a strong attachment. In the discharge of his duties as a professor, Mr. Millar delivered several courses of lectures in the university on the Roman law,—on the general principles of jurisprudence,—on government,—on Scotch law; to which, a few years before his death, he added a course of lectures on the law of England. He never wrote his lectures, but was accustomed to speak from notes, containing merely his arrangement, his chief topics, and some of his principal facts and illustrations. For the transitions from one part of his subject to another, the occasional allusions, the minor embellishments, and the whole of the expression, he trusted to that extemporaneous eloquence, which seldom fails a speaker who is well informed and deeply interested in his subject. The ability he displayed as a public teacher soon attracted a numerous concourse of students to his lectures, and contributed to raise the character of the university, of which he was a member, to a high degree of celebrity.

On his coming to Glasgow, Professor Millar became a member of the *Literary Society*, consisting chiefly of professors, together with some clergymen of the city and neighbourhood, which had been instituted in 1752; and he immediately proved himself a very active and zealous promoter of its views. He continued to attend its meetings with a punctuality of which there are few examples, during a period of forty years; reading discourses in his turn, and taking a lively interest in all its discussions. Having employed himself, for some years, principally in collecting materials for his various lectures, he afterwards found, that, notwithstanding his public duties, it was in his power to do justice to such young men as might be entrusted to his care as domestic pupils; and to their instruction he accordingly dedicated a very considerable part of his time.

Such were his regular and stated occupations during the winter. For some years after he was settled at Glasgow, he was in the habit of spending a great part of the summer with his father at Hamilton; but as his family increased, this plan became more inconvenient; and his uncle, Mr. Millar of Milheugh, ever attentive to the comfort of his nephew, gave him the small farm of Whitemoss, near the village of Kilbride, about seven miles from Glasgow, where he amused himself with agricultural improvements.

In the year 1785, Mr. Millar lost both his uncle and his father, who died within a few days of each other, and in consequence, he succeeded to the property of Milheugh, where he had an opportunity of gratifying his taste for agricultural pursuits and rural embellishment. During his residence in the country, however, he also employed a great part of his leisure in perusing such books as his other avocations in winter prevented him from reading, and in preparing his own works for the press. In 1771, he published his treatise *On the Origin of the Distinction of Ranks*, which was very favourably received, both in this country and on the continent; and in 1787, he gave to the world his *Historical View of the English Government, from the Settlement of the Saxons in Britain to the Accession of the House of Stewart.* These two are the only works to which Mr. Millar prefixed his name; nor does it appear that he published any other tracts, except one or two anonymous pamphlets on political subjects, and a few articles in the *Analytical Review*.

Amidst his other avocations, Mr. Millar found time for some limited practice as a lawyer, giving opinions, as a counsel, previous to the commencement of law-suits, and acting occasionally as an arbiter. He was also in the habit, for many years, of acting as counsel for criminals at the circuit courts of justiciary, where he exhibited uncommon skill and acuteness in the examination of witnesses, and a powerful and manly eloquence in his addresses to the jury.

Mr. Millar paid two visits to London, one in 1774, and another in 1792; at which latter period he arrived in sufficient time to be present at several very important debates in both houses of parliament; and he also enjoyed the satisfaction of becoming acquainted with Mr. Fox, and the other leaders of opposition, to whose principles he was warmly attached. The chief part of his time, however, was spent in the society of his former pupils, Lord Lauderdale and Mr. Adam, now Lord Chief Commissioner of the Jury Court in Scotland, and in the family of his old and much esteemed friend, Dr. Moore, author of Zeluco and Edward.

Mr. Millar had been uniformly zealous in his attachment to the party of the Whigs; and the French Revolution, at its commencement, rivetted his attention, and in its early progress excited his fondest hopes. When a similar spirit seemed to be called into action in this country, by the force of example, Mr. Millar became a member of the association known by the name of the Society of the Friends of the People, and he took a warm interest in all the political discussions of the times. Of course, he was decidedly hostile to all the measures of Mr. Pitt's administration, and in particular to those connected with the contest between this country and revolutionary France, which, with many other individuals, he regarded as injurious to the cause of liberty.

In 1791, he lost his second daughter, who was carried off by consumption; and in 1795, his wife died, after a long and painful illness. In the spring of the last mentioned year, his son, who had passed advocate, and got into business at the bar, emigrated to America; but soon after his arrival, he was struck with a *coup-de-soleil*, of which he almost instantly expired. This succession of melancholy events in his family, could not fail to produce a deep impression on the sensible mind of Mr. Millar; but after the first shock, he seemed to have recovered his self-possession. About the end of the year 1799, he was himself seized with a very dangerous inflammatory complaint, from which, however, after a few weeks of severe indisposition, he appeared perfectly recovered. In the month of May, 1801, he was again taken ill, after having exposed himself for several hours to a hot sun; and his complaint soon assumed the appearance of the most dangerous pleurisy, which terminated his life on the 30th of that month, in the 66th year of his age.

In his person, Professor Millar was about the middle stature; of a strong, active, and athletic, rather than an elegant form; and his countenance was uncommonly animated and expressive. He was very temperate in his mode of living, and regular in his habits of exercise. His manner, upon first entering a room, was not altogether free from formality and constraint; but this was only of momentary continuance. He possessed a wide range of information; and his conversation, whether upon subjects of a lighter or a graver kind, was lively, animated, and improving. He was completely conversant with literature and the *belles lettres*, took great delight in the Classics, and was familiarly acquainted with English, French, and Italian poetry. He was fond of argument, and exhibited great skill and dexterity in debate. On political subjects he always argued with zeal; and, towards the latter end of his life, with a considerable degree of keenness. In his political professions he was sincere, consistent, and disinterested; and the open and decided expression of his sentiments excited no feeling of personal hostility, even in the breasts of those who differed most widely from him in their opinions.

The style of his writings is very different from what might have been expected by those who had felt the vivacity of his conversation, and the copious diction of his extemporary eloquence. His language, as has been well observed by one of his friends, is the expression, rather than the ornament of his thoughts. Clear, accurate, and precise, it never fails to convey his ideas with a distinctness which precludes all misapprehension; but it frequently conveys them in a manner neither the most striking, nor the most alluring to the reader. Simple correctness and accuracy seem to be the only qualities he aimed at, and attained; even when he rises from plain narration to warmth and energy, the force is almost always in the principal idea, seldom in the accessaries. It is owing to this cause, perhaps, that his works are less popular than they would otherwise have been, had the style of the author been a little more attractive.

See Mr. Craig's account of the life of Professor Millar, prefixed to the edition of his treatise *On the Origin of the Distinction of Ranks*, published in 1806. (z)

MILO, anciently Melos, an island of the Greek Archipelago, about 60 miles in circuit, of a round figure, and penetrated on the north by a spacious bay, where the largest squadron may lie in deep water. The mountain St. Helias, which is the highest part, rises to a considerable altitude above the level of the sea: and another mountain, Calamo, which is supposed to have been a volcano of great antiquity, still emits fetid sulphureous smoke from several spiracles on its summit. Rocks of lava, sulphureous hot springs, mephitic exhalations, and many other circumstances, denote the frequent influence of subterraneous fires. The springs are impregnated with various substances; and, since the days of Hippocrates, they have been thought efficacious in the cure of diseases. Public baths are formed of one in a grotto where the vapour rises as in a natural stove. Porphyry, iron, gypsum, and the finest alum, obtained from a subterraneous gallery, where the thermometer stands at 108°, are among the productions of this island. There are salt marshes, or reservoirs, on the shore, filled by the sea-water in winter, which evaporates during the heats of summer.

The lower grounds of the island are extremely fertile and well cultivated, both in fields and gardens. Grapes, figs, melons, and olives, are abundant; also, wheat, barley, leguminous plants, and cotton. The fruits are said to be the best in the Archipelago, and the wine and honey are esteemed excellent. Besides mules, black cattle, sheep, goats, and swine, the domesticated animals, game is very plentiful.

Notwithstanding these advantages, the insalubrity of the climate is so great as to threaten the island with total depopulation. Little more than a century ago, the inhabitants were computed at 20,000; now they have dwindled down to 500; and were it not from the resort of families from the Morea, allured by the fertility of the soil, it is believed that the human race would become quite extinct.

The inhabitants follow agriculture, or pastoral pursuits; vast caverns throughout the island affording the latter convenient shelter for the flocks. Some are fishermen and pilots. The women are occupied in fabricating coarse stuffs and cotton stockings for home consumption, or for Europeans. Formerly, the hand-mills of Milo were celebrated from the quality of the stone; and were exported to the Turkish continent, the Ionian islands, Italy, and Egypt. But trade is almost annihilated from the decrease of the population, and the French privateers abandoning the Levant.

This island contains two towns, Milo, the capital, and Castro, or Sifours. The inhabitants of the former, who, in the beginning of last century, amounted to 5000, are now reduced to about 200, compared, by their visitors, to so many walking corpses. It is considered dangerous to sleep three nights here, and the town is in ruins. Castro occupies the lofty peak of a mountain, and is approached by a rock overhung by smooth basaltic rocks, which are almost insurmountable. The streets communicate by stairs. The slightest breeze resembles a hurricane; and the inhabitants attain very advanced age in this elevated situation. In the year 1700, Tournefort found 18 churches in Milo, 13 monasteries, besides many chapels, two bishops, and the rest of an ecclesiastical establishment, corresponding to a numerous population. Some of the monasteries still subsist, where later travellers meet an hospitable reception.

The site of the ancient capital is ascribed to an assemblage of ruins between the harbour and Castro, consisting of fragments of walls, some fine columns of granite, vaulted excavations, lined with cement, and the remains of bricks and pottery. On the opposite side of a deep ravine, there is a hill penetrated by an immense number of catacombs, which are gained by a subterraneous flight of steps. In general, seven sarcophagi cut out of the rock occupy each chamber, which are ornamented by sculptures, and exhibit the traces of painting on the cement with which they were lined; as also inscriptions now illegible. Several families have established their cottages above these catacombs, and convert the sarcophagi to cisterns for the winter's rain, which is employed in watering the fields below. The position of the ruins, their extent, the solidity of the walls, and the nature of the fragments, together with the great number of catacombs, are supposed to indicate the previous existence of a flourishing city, with temples, or other sumptuous edifices.

Melos is frequently mentioned in the history of the Grecian States; from which it passed under the dominion of the Romans, and on the decay of their empire was subjugated by the Turks, in whose possession it still continues, scarcely capable of paying an inconsiderable tribute. (*c*)

MILTIADES. See Athens, and Greece.

MILTON, John. This ornament of English poetry, and champion of English principles, was born in Bread Street, London, on the 9th of December, 1608. Few psrticulars are known respecting his family, except that it was respectable and ancient, that it had been long resident in Oxfordshire, and had once possessed considerable property, which was forfeited during the wars of the Roses. John Milton, the poet's grandfather, who was under-ranger of the Forest of Shotover, had disinherited the poet's father, whose name also was John, for becoming a Protestant. The young convert, who was then at Oxford, left the University in consequence of this misfortune, and applied himself to the profession of a scrivener in London, which, at that time, united the two businesses of law and money agency. It appears, from several circumstances, that he was no ordinary man—at least he was so considerable a proficient in music as to hold a considerable rank among the composers of the age. The poet's mother was, according to the testimony of her son, an exemplary women, and highly esteemed in the neighbourhood for her acts of charity. Her name was Caxton. Her family was originally from Wales. Our Milton was her eldest son. His younger brother, a lawyer and a royalist, was saved, during the republican government, by the interest of the poet, and after the Restoration was knighted, and made a Baron of the Exchequer, and a Judge of the Common Pleas, by James the Second. A sister, whose name was Anne, married Edward Phillips, a secondary in the Crown Office in Chancery. From this marriage sprung John and Edward Phillips. Both of them were the pupils of Milton, and one of them was his biographer.

The early genius of our immortal poet was fostered with such marks of judicious partiality as denoted his father's pride in the possession of so extraordinary a son. Aubrey relates, that the portrait of the youthful genius was taken by Cornelius Jansen in 1618, when he was only ten years of age, and that he was then a poet; and Dr. Symmons, in his life of Milton, notices this portrait being at present in possession of the family of Mr. Hollis. We presume that Dr. Symmons is accurate with regard to the date of the picture, though we have never heard of any print of Milton representing him earlier than apparently about his 19th year, and wonder that so curious a portrait should not have been made more known by engraving.

Some part of Milton's early education was committed to the care of Thomas Young, a puritan clergyman, who was compelled, by the persecution raised against the sectaries, to retire to the Continent, and was for some time chaplain to the British merchants at Hamburgh. It is not known at what particular time Young was the domestic tutor of Milton, but it is certain, that before his going to the University, our poet passed an interval of study at St. Paul's school, under the direction of Alexander Gill. The son and assistant of this schoolmaster was the intimate friend of Milton, as we find by three of the poet's familiar letters. He succeeded his father as master of St. Paul's school, but, what is disagreeable to relate of one honoured by such a friendship, was removed from his situation for excessive severity to the boys.

In his 16th year Milton was entered a pensioner at Christ's College, Cambridge, (Feb, 12. 1624) and was committed to the tuition of the Rev. William Chapel, the reputed author of the whole Duty of Man, and afterwards Bishop of Cork and Ross. Milton had at this time exercised himself in the composition both of Latin and in English verses. At 15, he translated and paraphrased two psalms, which he thought in maturer life worthy of the public eye. Dr. Symmons conceives, that in the highly poetical epithets of these boyish compositions, we may discover the first shootings of the infant oak which in later times was to overshadow the forest. We are rather inclined to think, with Dr. Johnson, that these productions excite no expectations—the boy Milton seems at that period not much greater than other boys, when he indites such a couplet as the following:

"The high huge-bellied mountains skip like rams
Amongst their ewes—the little hills like lambs."

The treatment and conduct of Milton at the University has been a fruitful subject of controversy. Dr.

Johnson good-naturedly fears that he was one of the last students in either University who suffered the public indignity of corporal punishment. The barbarous custom of public corporal corrections was no doubt retained at English Universities till about as late as the time of Milton, and from the savageness of the custom, and the utter ignorance of the science of education which it betrays, may easily be conceived to have been often dispensed by brutal tempers for acts of mere juvenile indiscretion. "C'est la crime fait la honte, et non pas l'echaufaud." So that, supposing Milton had been punished, unless the turpitude of his offence were proved, the anecdote needed not to have stirred up the pious concern of either his friendly or inimical biographers. It would only excite the disgust of a reflecting mind, to think that the barbarism of the monkish ages came so far down into the system of modern education; and if Milton was flagellated at college, and if the guardian spirits of human improvement have any thing to do with schools and colleges, they assuredly looked with an evil eye on Cambridge, in that hour when the spirit and pride of genius were exposed to the danger of extinction by a treatment so degrading both to the teacher and the taught. But Cambridge and Milton may both be easily acquitted of the suspicion of this occurrence. The story is a mere exhalation from the calumnies which were heaped upon his name by those who dreaded and felt his political eloquence—such as the son of Bishop Hall, and the Du Moulins and Moruses of his own day. His contemporaries believed not a word of the younger Hall's assertion, when he accused Milton of having been vomited forth from his university for disgraceful crimes; for Milton had unanswerable documents to produce at the moment, to show that he had been an object of regard and partiality among his superiors at Cambridge. But Aubrey, nevertheless, had heard of a rumour of Milton's having been punished at college—a rumour, however, which even Wood, ill-disposed as he was to the poet's memory, rejected as scandal—a rumour distinctly falsified by Milton's appeal in the face of the world to the members of his university, against the charge of ill-behaviour at college—and one which he could not have made without instantaneous detection, if he had ever been the object of ignominious punishment. But Thomas Warton would not let Aubrey's rumour drop, and Dr. Johnson, taking it up, and translating out of Milton's verses to Deodati, the Latin word *et cetera*, (meaning something else by "SOMEWHAT MORE," which it does not mean,) endeavoured to torture out of those verses the evidence of a fact which they will not yield. On Aubrey's rumour, and on Dr. Johnson's false translation, the story rests, and let it there rest in peace.

Early in the period of his college residence, we discover his progress as a writer both of English and Latin poetry. Perhaps the first of his English poems which can be fixed upon as an important date in the history of his genius, is his ode on the death of a fair infant, (his sister's child.) written at 17. He there manages with facility and effect a stanza similar to the Spenserian, though shorter, and evidently formed on Spenser's style. The thoughts rise to tenderness and sublimity, though sometimes blemished by conceit. His *Ode on the Nativity*, written at 22, discloses still greater beauties, and perhaps still deeper defects. The "*Verses at a Solemn Music*" have something peculiarly Miltonic; and his vacation exercise, on the subject of his native language, is pregnant with the first stirring-spirit of Paradise Lost, where he speaks of a subject of poetry.

> "Such, where the deep-transported mind may soar
> Above the wheeling poles, and at Heaven's door
> Look in and see each blissful deity," &c. &c.

Many of his Latin elegies were written as early as his 18th year. Ovid was his model in elegy. It has been regretted that he had not a model of greater strength, but to find power united with tenderness in classical elegy is not an easy task. Among his Latin verses it is interesting to meet with his description of a tender passion which he cherished at the age of 19. The object of it was a lady whom he saw in a public walk near the metropolis. She suddenly disappeared from him among the crowd, and he could never afterwards obtain any intelligence respecting her.

He took the degree of A. M. in 1632, and being now 24 years of age, left Cambridge to reside at Horton in Buckinghamshire, where his father lived after retiring from business. The five subsequent years which he passed under his father's roof may justly be regarded as the happiest of his life. To this favoured period we are indebted for some of the most exquisite productions of his genius. *Comus* and *Lycidas* were certainly written here, the former in 1634, the latter in 1637—and most probably the *Arcades*, *L'Allegro*, and *Il Penseroso*. The composition of the *Arcades* probably preceded that of *Comus*. The piece was written for the Countess Dowager of Derby, who resided at Harefield, in the vicinity of Horton. She was of the same family with Spenser the poet, and had been his patroness and his theme of praise before she was celebrated by Milton.

The *Arcades* is evidently nothing more than the poetical part of an entertainment, the bulk of which was formed of prose dialogue; and the attraction of which, to its spectators, probably depended much upon the spectacular show produced by machinery. But the poem, which was Milton's part of the entertainment, discovers a kindred, though inferior lustre of fancy to *Comus*. *The Mask of Comus* was acted before the Earl of Bridgewater, the President of Wales, in 1634, at Ludlow Castle, and the character of the lady and the brothers were played by the Lady Alice Egerton and her two brothers, the sons of the Earl of Bridgewater. The story of the piece is said to have been suggested by the accident of the Lady Alice having one night lost herself in the forest of Haywood. Dr. Johnson ascribes the origin of *Comus* to Homer's story of Circe; Hayley, however, has made it appear probable that it was derived from the Comus of Erycius Pateanus, which was republished at Oxford in the very year in which Milton's *Comus* was written. The elegy *Lycidas* was written in 1637, on the death of Edward King, one of the fellows of Cambridge, and the son of Sir John King, secretary for Ireland, in the reigns of Elizabeth, James, and Charles. The vessel in which he sailed from Chester for Ireland was lost in a calm sea, and not far from land. His memory was so highly esteemed by his university, that almost all the versifiers of Cambridge paid him a tribute. This was the last of Milton's works written whilst he resided at Horton with his father. *L'Allegro* and *Il Penseroso* were probably written but a short time earlier. Notwithstanding their Italian titles, they afford genuine English landscapes. They seem the works of a mind happy in every sense of the word.

They are little worlds of imagination, exhibiting, as it were, in fairy and concentrated miniature, the whole horizon of our pleasing or pensive associations. They have the truly angelic inspiration of a feeling of happiness, which they breathe and communicate both with and without gaiety. For Milton's melancholy man is as enviable a being as his cheerful one.

In his 30th year, with the concurrence of his father, he resolved upon an excursion to the Continent, chiefly with a view to the classic region of Italy. On the intimation of his design, he received a letter from the celebrated Sir Harry Wotton, who had resided at Venice as ambassador from James the First, and was now Provost of Eton. The compliment which Sir Harry pays to some of the poetry of Milton, which he had lately received from him, and to which he confesses that in its kind he had seen nothing parallel in our language, is remarkable, as perhaps the earliest token of superlative admiration which can be found to have been paid to his poetical genius. Certainly, at the time of his leaving England, we have no proofs of his general celebrity at home being in any degree equal to his genius. It is in Italy that we begin to perceive him adequately appreciated. He left England in 1638, attended by a single servant. At Paris we only learn that he saw Grotius, but have no means of ascertaining with what mutual sentiments they impressed each other. He proceeded from Paris to Nice, and embarking from thence to Genoa, proceeded through Leghorn and Pisa to Florence, at which place he remained for two months. He had studied the language and literature of Italy with the deepest attention, and thus accomplished, he soon obtained admission into the literary academies of the Florentines; became the object of their admiration, and the subject of their encomiums, which he says the Italian is not forward to bestow on men this side the Alps. Carlo Dati, Antonio Francini, Gaddi, Frescobaldo, and several other men, very respectable in Italian literature, were among his eulogists and almost worshippers.

A work entitled "*La Tina*," by Antonia Malatesti, was dedicated to him whilst at Florence; and the dedication of a work of even moderate merit to a stranger passing hastily through the place, and distinguished by neither wealth nor political importance, argues Milton to have then acquired no ordinary celebrity. The Italians thought so highly of his knowledge of their own language, that the academy Della Crusca consulted him on the verbal niceties of Italian. During his visit to Florence, he saw and conversed with Galileo, at that time a victim of ignorance and cruelty, having been imprisoned for his philosophical views by the Inquisition, and greatly reduced by sickness and mental distress. From Florence Milton passed through Siena to Rome, where he spent other two months. Here the kindness of Holstensius opened to him the curiosities of the Vatican, and introduced him to Cardinal Barberini, who at that time possessed the whole delegated authority of Rome, under his uncle Pope Urban the Seventh. At a great musical entertainment which this opulent churchman gave, Barberini looked for our traveller among the crowd at the door, and brought him, as Milton says, almost by the hand into the assembly.* At Rome he was praised in Latin epigrams by Salsilli and Silvaggi. He continued his route from thence to Naples, and falling into company with a hermit upon the road, was by him, from whom such a service could be least expected, introduced to the celebrated Manso, the patron and biographer of Tasso, who received him with flattering kindness and attention. The freedom with which Milton expressed himself on religious subjects was the only circumstance which deprived him of an unlimitedly free and intimate communication with this venerable nobleman, a circumstance which Manso himself commemorated in a well-known epigram. Undoubtedly the complimentary offerings of the Italians to Milton are not distinguished by merit as compositions, but we must regard them as the hasty though sincere effusions of men seeking to express their immediate feelings of enthusiasm, and not attending to what they wrote with the anxiety of authors writing for reputation. From a passage in Milton's address to Manso, we discover what he also mentions in one of his subsequent political writings,† that he already cherished the project of some great poetical work, "*which he should leave so written to after-times, that they should not willingly let it die.*"

The plan of his intended travels extended to Sicily and Greece; but as he was preparing to depart for Sicily, he received letters acquainting him with the near prospect of a civil war in England. He esteemed it dishonourable to be abroad whilst his fellow citizens were contending for liberty at home. He revisited Rome, however, and staid also at Naples for two months, excepting a few days which he passed at Lucca, the native place of the Deodati, the family of his beloved school-fellow of that name. From Florence he crossed the Appenines, and travelled through Bologna and Ferrara to Venice, where he staid a month, viewing the curiosities of the renowned city. Having provided for the safety of the books which he had collected in Italy, by procuring a place for them in a vessel bound to England, he pursued his returning course by Verona and Milan to Geneva. From thence he returned through France to his native country, after an absence of a year and three months. This was at the time of the King's return from his second expedition against Scotland, when his forces had been obliged to retreat before Leslie. The crisis was a striking one. Private griefs, however, must have been at this time mixed with Milton's sensations of interest in the public, as the first news which he heard on coming home was the death of his friend Carlo Deodati. He dedicated to his name his Epitaphium Damonis. From a passage in this poem, it appears that he still frequently thought of some great epic composition, and that Arthur and the heroes of British fable were at that time his meditated subjects.

Coming to London, he hired lodgings in St. Bride's church-yard, and received, as pupils, his two nephews, John and Edward Phillips. It has been asked, whether he took pupils gratuitously or for reward—we may go a step farther back, and ask what is the use of such a question? The business of teaching is still honourable, though it should reward the teacher with subsistence. It is of more importance to inquire how far his plan of teaching corresponded with the superiority of his intellect. It was formed, says one of his most admiring biographers, Dr. Symmons, on an erroneous principle—"It respected things more than words." This descrip-

* Ipse me in tanta turba quæsitum ad fores expectans, et pene manu prehensum, persane honorifice intro admiserit.—*Epist. Famil.*
† Reasons for Church Government.

tion certainly opens not unprepossessingly. He placed in the hands of boys from ten to fifteen years of age, such writers, as, though not remarkable for beauty of language, gave information on some of the departments of science, as, the agricultural works of Cato, Columella, and Varro; the Medical Treatise of Cornelius Celsus; Pliny's Natural History; Vitruvius's Architecture, and the philosophical poems of Lucretius and Manilius. We perceive in this plan the teacher's laudable ambition to imbue the minds of those entrusted to him with an early love of science, as well as the recollection of words and phrases, and cannot agree with Dr. Symmons that it is founded on false principles. Sir William Jones followed the plan of education traced out by Milton; and if we may judge of a system by its disciple, he could not have pursued a better.

From St. Bride's Church-yard he soon removed to a house in Aldersgate Street, which admitted his scholars into his family, and the situation, secluded by a court from the street, and opening behind into a garden, supplied the retirement favourable to literary occupation. Here he gave his pupils the example of close application and abstinent diet. He indulged only in temperate festivity once in the course of a month or three weeks. "His companions," Phillips says, "were the beaux of the times, but they never were so intemperate as those of the succeeding generation."

The state of politics brought his pen into exertion. The long parliament now represented a nation irritated by the flagrant abuse both of civil and ecclesiastical power. The king's treatment of members of parliament, one of whom, Sir John Elliot, had died from the severity of imprisonment; his arbitrary exertions, and the severe sentences of his courts and councils, had made the public ripe for resistance and innovation; and the despotism of the church had walked side by side with that of the state. But Charles's embarrassments after his defeat from the Scottish army compelled him to have recourse in earnest to a parliament; and this legislature released the press from its horrid silence. Milton, on his return from the Continent, found the clamour loud and general against the bishops. He was on this occasion, to all appearance, the leader of the attack on the church, as far as the hostility of the press was concerned. In his two treatises of reformation touching church government, he contended that the reformation of the church had not proceeded sufficiently far; and inveighed against the practical evils which religion and liberty had suffered under the prelatical government. To this and other attacks from puritan pens, the virtuous and learned Bishop Hall thought it proper to reply, in "A Humble Remonstrance to the High Court of Parliament;" and about the same time Archbishop Usher published a work to maintain the apostolical institution of Episcopacy.

In reply to these pamphlets, Milton published two pieces, the first of which bore the title of "*Prelatical Episcopacy*," and the second, "*The Reason of Church Government urged against Prelacy*." The point at issue between these polemics was the divine or the human origin of episcopacy. These opponents of our author, Hall and Usher, were men whose characters reflected honour upon their cause, and who, in their conduct, were not persecutors. This circumstance, however, is not decisive of the truth of the ecclesiastical doctrines which they supported. Milton's productions were the most learned and able on the puritan side of controversy. But the piece which seems to have chiefly attracted the public attention at this time, was one written by five of the presbyterian divines, under the title of "*Smectymnuus*," a word made up of the initial names of the authors. To this book Bishop Hall replied in a "Defence of the Remonstrance," and Milton's formidable pen produced "*Animadversions on the Remonstrant's Defence*." These five pieces of Milton's were written in one year, 1641, when their author was thirty-three years of age, and whilst he was daily occupied with the fatigues of tuition.

In the beginning of the next year, his "*Animadversions*," which unquestionably were rude and personal, excited a deeply vindictive reply (as was supposed) from the son of Bishop Hall. The anonymous publication heaped enormous falsehoods on Milton's head. Our author's "*Apology for Smectymnuus*," was drawn forth by this accumulated provocation. The most objectionable part of this work is the critical attack which he makes on Bishop Hall's literary character, and on his satires: its most splendid and eloquent passage is his eulogy on the first proceedings of the Long Parliament. This publication seems to have closed the controversy; weapons more effectual than pens were now drawn against the church.

About Whitsuntide, in 1643, Milton took a journey into the country, apparently for the mere object of recreation; and, without having communicated his design of marriage to any of his friends, returned, rather to their surprise, at the end of a month, with his wife, Mary Powell, the daughter of a country gentleman, at Forest Hill, near Shotover, in Oxfordshire. His matrimonial choice seemed to be hasty, and was not fortunate. His spouse, strongly attached, like all her family, to the royalist party, and accustomed to the affluent hospitality of her father's house, was soon tired of a studious, recluse, and republican husband. After a month's experience of her new life, she sighed for the gaieties she had left behind, and by the earnest request of her relations obtained permission to pay a short visit to Forest Hill. But when the period returned, (Michaelmas,) when she should have arrived, she shewed no disposition to keep her word; but, on the contrary, treated his letters with silence, and sent back his messenger with disdain. The king at this period was defeating the parliamentary forces, and the Powells were disposed to break as well as they could an inauspicious connexion. On the other hand, Milton determined to repudiate a wife who left him nothing of matrimony but the chain. To justify the intended measure, he published, in 1644, an essay on the *Doctrine and Discipline of Divorce*. This treatise, which was incribed to the parliament, was soon followed by "The judgment of Martin Bucer concerning divorce," and by *Tetrachordon* and *Colasterion*. The two last of these tracts were written in 1645—the latter of them as a reply to an anonymous antagonist, the former as an exposition of the four passages in scripture, which are supposed to relate more immediately to the permanence of the marriage obligation. By these writings, the fury of the presbyterian clergy was instantly excited; they endeavoured to infuse their passion into the legislature, and occasioned Milton to be cited before the House of Lords. But he was speedily and honourably dismissed from this tribunal, and the Presbyterians lost an able friend, and excited a formidable enemy. Milton was serious in his opinions, and prepared to act upon them. Conceiving himself released in conscience from the marriage bond, he paid his addresses to an accomplished and beautiful young lady, the daughter of a Dr. Davis. The lady, it has been intimated, was rather averse from the proposal, but her objections (and her friends seem not to have stated any,) were apparently slight, when the match was prevented by the return of his delinquent spouse. Public affairs were now changed. The tide of fortune was against the royalists, and the Powells, foreseeing, what the event proved, that Milton might protect and assist them, hastened to propitiate his resentment. They concerted with Milton's friends to introduce his wife unexpectedly into his presence at a friend's house, and she supplicated for her pardon upon her knees so effectually as to obtain it. He admitted, along with her, to his house, the family of the Powells, who were now in danger and distress, and saved the bulk of their property by his interest with the victorious party. Whatever gratitude the Powells felt, they never did him the justice to pay his wife's fortune out of their rescued estate. But, it is possible, that in such times the recovery of property might be more nominally than really complete. They remained under his roof for many years, which, unless their spirit was extremely abject, would argue that they were late in regaining their estate, and in the interval it must have suffered much deduction. In the mean time, to accommodate his enlarged family, our author hired a house in Barbican. In the year 1644, whilst immersed in his controversy about divorce, he published his ideas on the subject of education, and not long after sent forth his work Areopagitua, in which he defended the freedom of the press with a degree of intelligence and spirit which has never been surpassed.

The Presbyterians, on their arriving at power, forgot the principles which they had professed in their rising to it, and placed the press under the same controul of which they had of late so indignantly complained. Milton came forward as the champion of free discussion, and made his weapons of reason and fancy as effective by their weight and edge, as they were dazzling by their brightness. Though the presbyterians could practically resist the adoption of his principles, they could not prevent his arguments being heard and felt. The office of licenser of the press was indeed continued throughout the whole duration of their power, but at a subsequent period, (in 1649,) we find the conscientious Gilbert Mabot resigning this invidious office, and in stating the grounds and motives of his conduct, repeating the arguments for a free press contained in Milton's Areopagitua.

In 1645, Milton once more courted the Muses, whom he had so long deserted. From the period of his return to England to this year, his pastoral on *Deodati*, and some occasional sonnets, were the only poetical fruits of his genius. He now prepared an edition of all his English, Italian, and Latin poems. The small volume which they formed was published with his name, and with a preface by their publisher, Humphrey Mosely. The sonnets were the most important novelties of the collection.*

In 1646, his wife brought him their first child, a daughter, named Anne, who was lame, either from her birth, or in consequence of some accident in her early infancy. In 1647, his venerable father died under his roof, having come to live with him since the year 1643, when at the capture of Reading, he left his residence with his younger son in that city. The Powells left him not long after, and his house, (says Phillips,) looked once more like a house of the muses. In this same habitation, in the Barbican, his second daughter Mary was born. In the spring of 1647, he removed to a smaller one in High Holborn, the back part of which looked into Lincoln's Inn Fields.

Phillips relates, that in the course of the civil wars there was a proposal for Milton embracing the military life; and says that, if he was not much mistaken, there was a design of making him an adjutant-general in Sir William Waller's army. Dr. Johnson ridicules this vague allusion to an unfulfilled intention. Yet we may ask, what there is ridiculous, either in the rumour, or in Phillips's taking notice of it. If Milton was not employed in the field, it was because he could fill the post of intellectual warfare with more advantage. His laurels at that post were more honorable than the field of battle could afford him; and in that field there was no combatant but himself who was capable of earning them.

After the works already mentioned, he is not known to have published any thing earlier than his treatise, which appeared early in 1649, entitled *The Tenure of Kings and Magistrates, &c.* maintaining the right of the people to depose and put to death a tyrannical king. The unfortunate Charles I. had suffered on the scaffold. Milton's work therefore came forth, not to accelerate Charles's fate, but, as he expressly declares, to tranquillize men's minds in the agitation which his fate produced. The pity which King Charles's tragic story excites,—a pity, however, by no means irreconcileable in humane minds with the conviction of his conduct having been deeply culpable, should not lead us hastily to regard the attempt at tranquillizing men's minds after his death as unprincipled. On the contrary, Charles had no sooner died, than compassion for him was made the pretext for men avowing slavish principles of the most abandoned nature. It was proclaimed as a fundamental maxim of government, that kings were from God, and not responsible to man; and this maxim too was avowed in some instances by men, who, at an earlier stage of the civil wars, had paved the way for the very dethronement and death which they now hypocritically lamented.

Without denying that Milton, in the sternness of his republican opinions—and, let it be allowed, even in the infectious taint of over-heated party zeal—may have regarded Charles with less humane allowance than the candid eye of an impartial posterity regards him; yet still it must be remembered, that this work professed not to discuss the question personally respecting Charles, but respecting the abstract principle of human rights and regal responsibility, at the root of which the anti-regicides were now striking. Whatever treatment it might have been true and humane policy to have imposed on the fallen monarch, it was not to be tolerated, that his fate should be called in question, on the atrocious principle that kings are not responsible. So that Milton, as far as abstract principle was concerned, is not to be viewed in the light of one contributing to shed Charles's blood, but to be justified for slaying the monstrous opinions that rose out of it.

* The whole of his sonnets, however, were not included in this collection. Some of them were written at a subsequent period.

His next work was a pamphlet on the articles of peace, which the Earl of Ormond concluded at Kilkenney in the king's name with the Irish insurgents.

Without imputing to Charles any participation in the horrible massacre of the Irish protestants, it is clear that the treaty with the Catholics, concluded under the king's name and authority by Ormond, was sufficient to confirm the public prepossession on the subject, and to give an appearance of the tone of truth to republican and puritan invective. Milton, therefore, found it not difficult to be severe on the articles of a peace, which by abandoning the English and Protestant cause in Ireland, permitted their enemies to indulge in sanguinary revenge. When he had concluded this attack, he returned to the more quiet occupations of literature, and finished four books of his history of England. These come down no farther than the union of the heptarchy under Edgar. Two other books, written at a subsequent period, namely, after his controversy with Morus, bring the narrative as far as the battle of Hastings. It is a history unfortunately terminating at the period where our annals begin to be interesting; but the materials are copious and curious, and the style energetic, though occasionally harsh. The first book is abandoned without reserve to the fables of Geoffrey of Monmouth, and was intended, as the author intimated, rather to suggest subjects to the poet, than maxims to the statesman or sage.

On the death of Charles I. the executive power of the commonwealth was lodged in a council of 38 members of the legislative assembly, who made England for a time command the respect and terror of Europe. Resolving to adopt the old Roman language in their intercourse with foreign powers, they appointed a Latin secretary; and the learning, talents, and republicanism of Milton, pointed him out as the person best fitted to fill this office. The younger Vane and Bradshaw, who have both been the subject of his panegyric, are supposed to have first suggested his appointment. His continuance in this office was prolonged to the Restoration; and the state papers in his department were models in the class of diplomatic compositions. Those letters in particular which he wrote in the Protector's name, to mediate for the oppressed Protestants of Piedmont, reflect a lustre on the reign of Cromwell, and on the history of England.

Milton had scarcely entered on the proper functions of his office, when he was summoned by the new government to the discharge of another and peculiar duty. One of the contrivances of the royalists after the death of Charles, to stimulate public enthusiasm in their cause, was to publish the Eikon Basilikè, or portrait of his sacred majesty in his solitude and sufferings. The book was given out to be a collection of the feelings and reflections which Charles I. had at various times during the civil wars committed to writing. It represents him in the constant intercourse of prayer with his Maker, asserting the integrity of his motives before the Searcher of hearts, and appealing to his justice from the injustice of man. There are few men, whose conduct through life would sanction them in writing such a diary, to make conscientiously such constant appeals to the Deity in favour of the purity of their motives, and Charles was neither so pure as to be able to make them with a safe conscience, nor so hardened as to have made them with cool hypocrisy. It has been ascertained, by proofs which no reasonable man can reject, that this book, representing him as a saint and a martyr, was written for the political ends of the royalists by Dr. Gauden; and it is remarkably curious, that the most decided confession of the spuriousness of the Eikon was made by Charles's own sons Charles II. and the Duke of York.* The work. however, was considered as genuine when Milton wrote his remarks on it, although there were internal symptoms against its authenticity which his sagacity could not overlook. The council of state saw the dangerous impression which the Eikon Basilikè was calculated to make. They might have suppressed it by force; but they preferred waging war, by opposing argument to argument, and book to book. Milton, at their desire, wrote the *Iconoclastes*, or image-breaker, in which he disclaims the intention of insulting the memory of Charles, but confronts the monarch's actions with the piety ascribed to him, and has even hinted at the work having been manufactured for him by his household rhetorician,—a suspicion which time has verified.

Milton's memory has been charged with three several offences in the *Iconoclastes*, or *Image Breaker*. In the first place, with having too rudely blamed the king for making use of a prayer which he borrowed from a romance, namely, Sir Phillip Sydney's *Arcadia*; in the next place, with having interpolated the *Eikon Basilikè* with that prayer, in order that he might establish a ground of censure; and, in the third place, with having uncharitably insulted Charles's *memory*, on account of his intimacy with the plays of Shakespeare. The first accusation is true, the two others are absurd. He did, with unnecessary harshness, animadvert on Charles's having borrowed a prayer from a romance, but he did not interpolate the Eikon; for in the first edition of the Eikon, printed by Royston a royalist, the prayer in question is to be found. His animadversion on the king's fondness for Shakespeare is perfectly unblameable: the gust of all that he says is merely to convey the remark, that pious and clement sentiments have often been put into the mouths of tyrants, and by no poet more than by Shakespeare, with whom Charles I. was so well acquainted.

On being appointed to the office of Latin secretary, Milton removed first to a lodging at Charing Cross, and afterwards to apartments in Scotland Yard. In this last residence his wife had her third child, a son, who died in his infancy, on the 16th of March, 1650. In 1652, he changed his abode to Petty France, where he occupied, till the Restoration, a handsome house opening into St. James's Park.

He had no sooner finished his *Iconoclastes*, than he entered into his controversy with Salmasius. This learned Frenchman, (Saumaise, or Salmasius.) an honorary professor of Leyden, was employed by Charles II. to write the *Defensio Regia*, or an appeal to the world in behalf of the cause of royalty, prelacy, and the house of Stuart. Milton was employed to answer it, and he performed his task in 1651, by his celebrated *Defensio pro Populo Anglicano*. He was present when the council of England enjoined him the task. Milton, when he undertook it, was weak of body and dim of

* When a copy of the *Eikon* was sold among the books of the first Earl of Anglesea, a memorandum was found in it, in that nobleman's handwriting, attesting that Charles II. and the Duke of York had disavowed the *Eikon* as the work of their father.

sight, and his physicians predicted that it would cost him the loss of his eyes; but he persevered, and finished a work, the eloquence and intellectual power of which is only slightly disfigured by some sportive sallies of wit, and some harsh personalities. The work was applauded by all Europe. Foreigners of the highest talent and erudition, and the ambassadors of crowned heads, waited upon him, or wrote to him to express their congratulations. The council of state made him a pecuniary reward of a thousand pounds.

On the 2d of May, 1652, his family was increased by the birth of another daughter, Deborah, of whom his wife died in child-bed. Meanwhile his sight was impaired by incessant study, so as to leave him probably as early as this same year nearly blind, at least one of his adversaries about that time charitably upbraids him with the calamity as a punishment from heaven, and denominates him as a "*monstrum horrendum cui lumen ademptum.*" His fortitude under the event is admirably expressed in his sonnet to Cyriac Skinner.

The precise date of his second marriage, is not much better ascertained than that of his confirmed blindness, though probably both events took place about 1654. His second matrimonial choice was Catherine, the daughter of a Captain Woodcock of Hackney. She was the object of his fondest affection; but died within a year after their marriage, like her predecessor, in child-birth, and the daughter whom she bore to him soon followed her to the tomb. His sonnet to her memory must be in every one's remembrance. During this period his powers were again employed in controversy.—De Moulin's "*Cry of the Royal Blood to Heaven*," published in 1652, poured forth the most violent abuse against the English as a nation, and Milton as an individual. De Moulin, the son of an obscure French satirist at Sedan, was the real author of this work; but Alexander More, a man of Scotch parentage, and a preacher of considerable celebrity, settled in France, and Principal of the Protestant College of Castres, wrote a dedication of the *Clamor Regii Sanguinis* to Charles II. and committed it to the Press; on him, therefore, Milton retaliated with a vengeance which sufficiently exposed the impeachable part of More's character. With his *Second Defence of the People of England*, Milton closed for the present his controversial labours; and probably endeavoured among his studies to retire from the mortification and disappointment which he felt from the exhibition of despotic principles and conduct in the Protector. There is reason to believe that he felt this mortification. Like Blake and Sir Matthew Hale, he might plead the employment of his country as lawful even under a tyrant, and he might think a temporary usurpation, on the whole, preferable to the return of the unprincipled royal exiles. But it would have been agreeable to have had a more distinct declaration of his motives from his own pen. He was engaged in 1653 in continuing the History of England, and a Latin dictionary, and had begun to frame his immortal epic poem. The historical work, which is only a great fragment, appeared in 1670, mutilated by the licenser of some of its finest passages. The materials of his Latin Thesaurus were left imperfectly digested, but are said to have been usefully employed by the compilers of the Cambridge Dictionary, to whom they were probably given by his nephew Phillips. In the same year he published a MS. of Sir Walter Raleigh's, consisting of aphorisms on the art of government, and composed in a strain of peculiar elegance the manifesto issued by the Protector in justification of his war with Spain. In the following year Cromwell finished his splendid but criminal career, and his son Richard descended with magnanimous innocence to the safe level of a private station. When the fluctuations of government threatened general anarchy, Milton was induced to give his advice on civil and ecclesiastical topics, in some short publications; one of which was, a ready and easy way to establish a free commonwealth; the excellencies thereof compared with the inconveniences and dangers of re-admitting monarchy. This appeared but a short time before the restoration, so zealous and sanguine was he to the very last with respect to his political system. It was in vain, however, to contend with pamplets against the national inclination. The king returned in triumph; and Milton, discharged from office, left his house in Petty France, and was secreted under the roof of a friend in St Bartholomew's close, near to West Smithfield, till the act of oblivion, in the exceptions to which he was not included, ascertained his safety and reinstated him in society.

All parties have agreed in paying this compliment to Charles II. that it was owing to no weakness or oversight of his, if Milton escaped. It is supposed that his friend Andrew Marvell, the member for Hull, made some interest for him in the House of Commons; and we are told that Sir Thomas Clayes, and Secretary Morris, made exertions for his preservation. But the most earnest and grateful interposition seems to have been that of Sir William Davenant, who had been saved on a former occasion by the mediation of Milton. But though his person was spared, his *Iconoclastes, and the Defence of the People of England*, were condemned to be burnt by the hands of the hangman. Milton might well smile at this vindictive show of triumph. No sentence, no hangman, no flames could destroy the fame of the *Defence of the people of England.* He might also console himself by reflecting, that those who sentenced his book to be burnt, were the same who dug up the body of Blake to be hung on a gibbet, and who brought back the punishment of embowelling on the scaffold, ere they were yet dead, the expiring victims for treason; a relic of barbarism which had been abolished during the republic. Milton was for some time in the custody of the Serjeant-at-Arms, but was discharged, and attention was even paid to his complaint of the demand of excessive fees. This attention, however, was paid to him by the parliament, and not the crown.

Being now in reduced circumstances, and under the discountenance of power, he removed to a private habitation in the city, and, in order to alleviate his forlorn condition, he desired his friend Dr. Paget to look out for a third wife for him. He recommended a relative of his own, Elizabeth Minshull, of a good family in Cheshire, and the union took place in Milton's fifty-third or fifty-fourth year. About the time of his marriage, or probably a little before it, he published a short treatise, entitled *Accidence Commenced Grammar*, intended to facilitate the first weak step of the juvenile student, and remarkable only for its exhibition of a mighty mind stooping in dignified condescension to utility. In 1655, he gave to the public another MS. of Sir Walter Raleigh's, containing aphorisms of State, with the title of the "*Cabinet Council.*" That he was offered from the court, and refused the post which he had held under the former government, has been asserted, but with little probability, since his manners were by no means accommodated to the new reign, and he had offended too deeply to be more than forgiven.

He had now to resume the character of a poet, which for many years had been sunk in that of a politician and controversialist, for his few compositions in verse during this period, though exquisitely beautiful, were not sufficiently attended to, to add to his poetical reputation. When he first formed the resolution of writing an epic poem, he thought of some subject in the heroic times of English history. Religion and the study of the Hebrew Scriptures decided him in favour of a religious subject. His mind, now concentrated and undisturbed, fulfilled the great conceptions which he had designed of *Paradise Lost*. The exact time employed in the composition of this poem is not ascertained, but it probably occupied his thoughts with no considerable interruptions of any other literary subject for eleven years, from 1654 to 1665, at which period Elwood the quaker says it was finished; a time when Milton, to avoid the contagion of the plague in London, made a retreat to Chalfont in Buckinghamshire. Paradise Lost was first printed in 1667, in small quarto, and divided into ten books; and his biographers have been very minute in recording the trifling sum which he received for the copy-right of it. Much discussion has also taken place respecting the original conception of this grand performance. Voltaire first suggested, that the hint had been given by the Adamo, a poor drama, full of allegory, conceit, and bombast, written by one Andreini, a strolling player of Italy. Dr. Johnson rejected the hypothesis with contempt, but from the circumstance distinctly proved, of Milton's poem being first projected by him in a dramatic shape, and from the similarity of the allegorical beings first sketched by Milton with those of Andreini, it seems by no means improbable, that the supposition suggested by Voltaire, and illustrated by Mr. Hayley, is correct.

In the second edition of the *Paradise Lost*, which was published in 1674, the author divided the seventh and tenth books, for the purpose of breaking the length of their narrative, each into two, and thus changed the original distribution of his work, from ten to twelve books. On this new arrangement the addition of a few lines became necessary to form a regular opening to the eighth and the eleventh books; and these nine verses, with six others, inserted partly in the fifth and partly in the eleventh, constituted all the alterations for this mighty production, on which his own and the epic fame of his country was to rest.

Paradise Regained, written upon a suggestion of Elwood's, and apparently regarded by the author as the theological completion of this plan, followed in 1670. He is said to have viewed this production with the partial fondness of a parent for his latest offspring. He could not bear the disparaging comparison of it with his great work, which was generally made. The general opinion of this poem certainly places it at an humble distance from *Paradise Lost*. The extreme narrowness of its plan, the small proportion of it which is assigned to action, and the larger portion which is given to disputations and didactic dialogue, its paucity of characters and poetical imagery, and its general deficiency in the charm of numbers, exclude it from a wide range of popularity. It is embellished, however, with several exquisite passages, which discover the still existing author of the *Paradise Lost*. *Sampson Agonistes* was published at the same time, a manly, noble, and pathetic drama; though it cannot be asserted that its action is undefective, or that all its scenes tend harmoniously to the developement of the fable. The unlimited and capricious wanderings of the choral measures are also such as would be likely to offend us, if we were not prejudiced by the consciousness of reading Milton.

The poet, in this respect, imitated the Greek drama, which unites in its choruses verses of all descriptions, without any rule which modern scholarship can ascertain. But the vocal structure of the Greek language might admit of harmony with great irregularity of measures; and Athenian ears might learn by habit to delight in such anomalous harmony (if it was anomalous.) whilst our more obdurate tongue requires the precincts of verse to be distinct and definite; and we are habituated to delight chiefly in the flow of measure which the ear competently understands, and which it in some degree anticipates.

With this piece the history of Milton's poetry closes; but writing was become so much a habit with him, that he was continually making additions to his works in prose. In 1672, he published a system of logic, after the method of Ramus, and in the following year he again ventured into the field of polemics, with a treatise *Of True Religion, Heresy, Schism, and Toleration, and the best means to Prevent the Growth of Popery.* So imperfectly was toleration then understood, that Milton persuaded himself he was consistent in denying it to Papists, although he declares that he would not even towards them exercise any personal severity.

In 1674 he published his familiar letters, and some of his university exercises; the former with the title of *Epistolarum Familiarum Liber unus*, and the latter with that of *Prolusiones quaedam Oratoriae in Collegio Christi habitae.* It has been commonly affirmed that he translated into English the declaration of *the Poles on their elevating the heroic John Sobiesko to their elective throne*; but Dr. Symmons throws some doubt upon the fact, as the Latin document could have arrived in England only a very short time before his death; and as the translation bears no resemblance to his character of composition. It is more certain that in some part of the same year, the last of his life, he wrote a brief history of Muscovy, which was published about eight years posterior to his death.

With this work terminated his literary labours; the gout, which had for several years afflicted him, in spite of his extreme temperance, seems to have brought on rather premature senility and exhausted his vital powers. In his sixty-sixth year, and on the 8th of November 1764, he expired, so quietly that those who waited in his chamber were not conscious of his death. His funeral was attended by many great and learned individuals, and not without a friendly concourse of the vulgar; his remains were deposited by the side of his father's, in the upper part of the chancel of St. Giles's, Cripplegate. In consequence of an alteration made in that part of the church, the stone originally inscribed with his name was removed at the end of a few years, and was never replaced. But this unintended injury was in later days compensated by the erection of his bust, (the work of Bacon) at the expence of the elder Mr. Whitbread. Mr. Benson, one of the auditors of the impost, had, in 1737, introduced a similar memorial of

Milton into Westminster Abbey. By his will he left nearly £2000, besides £1000, his first wife's portion, which remained in the hands of the Powells, and which ought to have been paid, if it was not, to his daughters. He had lost £2000, the emoluments of his office, which he had placed on government security.

Milton was distinguished in his youth for personal beauty, and continued to be a well-looking man to the last.* He was a skilful swordsman, vigorous and active in his exercises, manly and erect in his deportment. He was also, like his father, accomplished in music, though not a composer. His learning embraced the Hebrew, Greek, Latin, and Spanish, and, if not absolutely versed in the sciences, he had penetrated more than their surface. Though from parts of his controversial writings, we might presume his temper to have been harsh, he indulged in no enmities except on public grounds, and in private he was mild and courteous. This we have on the authority of F. Junius, the author of De Pictura Veterum, and H. Heinsius mentions the general report of the amenity of his manners—"Virum esse miti comique ingenio aiunt."

His prose compositions vary in merit. The earliest of them possess a more crude and unwieldy character of strength. As he continued to write prose, there is a visible, though not equally progressive improvement. In a general view of them, there is a strength and spirit of genius rising often to grandeur, but a deficiency of taste to purify, and harmonize, and perfect, the powers of expression. The picturesque is often redundant and out of keeping, and the structure of his sentences laboriously scholastic.

The homage paid to his poetical genius is so universal, that we shall not distend our article with a critical dissertation on them. Addison made his own generation sensibly alive to the beauties of Paradise Lost, though there is reason to believe, that, even before the time of Addison, the great Epic was not so much neglected as has been often alleged. Since the middle of the last century, the public attention has been more and more drawn to his minor poems, till it may be said to be now rivetted on them with almost unqualified extacy. Of Paradise Lost it has been justly remarked, that, in forming our estimate of the powers of mind possessed by different races of men, it raises our opinion of the strength and magnificence of the English imagination. It is a sublime work, that adorns our country more than "cloud-capt towers or gorgeous palaces." Even its imperfections seem to be unavoidable, and to have arisen out of its theological subject in a way, in which, with few exceptions, it is difficult to conceive how the author could have well avoided them. But taking the subject all in all, (we quote Mr. Campbell's Essay on English Poetry.) his powers could no where else have enjoyed the same scope. It was only from the height of this great argument that he could look back upon eternity past, and forward upon eternity to come, that he could survey the abyss of infernal darkness, open visions of Paradise, ascend to heaven, "and breathe empyreal air." On the style of Milton, and on the most sublime trait of excellency in his poem, namely, his delineation of the celestial and infernal angels, we beg to conclude with a quotation from the critical work already mentioned. "If we call diction the garb of thought, Milton in his style may be said to wear the costume of sovereignty. The idioms of other languages contributed to adorn it. He was the most learned of poets, yet his learning interferes not with his substantial English purity. In delineating the blessed spirits, he has exhausted all the conceivable variety that could be given to pictures of unshaded sanctity; so that his excellence above every thing, ancient or modern, is conspicuous. Tasso had indeed pourtrayed an infernal council, and had given the hint to our poet of ascribing the origin of Pagan worship to those reprobate spirits. But how poor and squalid in comparison of the Miltonic pandemonium are the Scyllas, the Cyclopses, and the chimeras of the infernal council of the Jerusalem. Tasso's conclave of fiends is a den of ugly incongruous monsters:

> "*O come strane o come orribile forme,*" &c. &c.
>
> La Gerusalemme, Canto iv.

The powers of Milton's hell are godlike shapes and forms. Their appearance dwarfs every poetical conception, when we turn our dilated eyes from contemplating them. It is not their external attributes alone which expand the imagination, but their souls, which are as colossal as their stature—their thoughts that wander through eternity—the pride that burns amidst the ruins of their divine natures—and their genius, which feels with the ardour, and debates with the eloquence of heaven.

The subject of "Paradise Lost" was the origin of evil—an era in existence—an event more than all others dividing past from future time—an isthmus in the ocean of eternity—the theme was in its nature connected with every thing important in the circumstances of human existence, and, amidst these circumstances, Milton saw that the fables of Paganism were too important and poetical to be omitted. As a Christian he was entitled wholly to neglect them, but as a poet he chose to treat them not as the dreams of the human mind, but as the delusions of infernal existences. Thus anticipating a beautiful propriety for all classical allusions, thus connecting and reconciling the co-existence of fable and of truth, and thus identifying the fallen angels with the deities of "gay religions full of pomp and gold," he yoked the heathen mythology in triumph to his subject, and clothed himself in the spoils of superstition." (*n*)

MINDANA. See Magindanao.

MINDEN, or Munden, a city in the kingdom of Hanover, and principality of Calenburg, is situated on the Weser, which is crossed by a bridge 600 feet long. It is about two miles in circuit, and encircled with walls and ramparts. The principal public buildings are, the Hotel de Ville, the cathedral, which is a fine edifice, the church of St. John, the Gymnasium, and the Orphan's

* The venerable figure of Milton is described by Richardson as he was sitting (according to custom) before his door, in a great coat of coarse cloth in warm weather to enjoy the fresh air, and thus receiving visits of persons eminent for talents or consideration. Richardson proceeds to say, "Very lately I had the good fortune to have another picture of him from an ancient clergyman in Dorsetshire, Dr. Wright He found him in a small house, he thinks but one room on a floor; in that, up one pair of stairs, which was hung with rusty green, he found John Milton sitting in an elbow chair, black clothes, and neat enough; pale, but not cadaverous; his hands and fingers gouty and with chalk stones. Among other discourse, he expressed himself to this purpose, that was he free from the pain this gave him, his blindness would be tolerable.

House, where there is a manufactory of stockings. It has three Lutheran, one Calvinist, and two Catholic churches. The principal manufactures in this place are those of wax candles, hats, leather, and soap. There are also refineries of sugar and bleach-fields. The white beer of Minden has been long celebrated. An account of the battle of Minden, fought here in 1759, will be found in our article BRITAIN. Population, 7000. East long. 8° 53′ 26″. North lat. 52° 17′ 47″.

MINE,

An excavation made either in the rock, strata, or in the earth which generally covers the rock, of which there are three distinct kinds, viz.

1*st*, A mine employed in the art of war, particularly in sieges.

2*d*, A mine made for the working of veins, containing the ores of metals; which veins are generally in a position nearly vertical.

3*d*, A mine for the working of such minerals as generally lie in beds, having a moderate angle of inclination with the horizon, such as a *coal-mine*, an *ironstone-mine*, or *limestone mine*,

The first kind of mine will be found described in the article FORTIFICATION.

The second kind will be described under the article VEIN.

The third kind, in particular the *working of coal-mines*, will be now described.

Although mineral coal is found abundantly in various quarters of the globe, as noticed under the article COAL, it is admitted that the most valuable fields of it are found in Great Britain, and have been wrought to a much greater extent there than in any other part of the world.

As nothing but pit-coal is used as fuel for domestic purposes in Great Britain, excepting in a few of the inland districts, where a small quantity of wood and turf are substituted; and as all the numerous and extensive iron-works, with the innumerable steam-engines and manufactories, depend entirely upon a regular supply of coal, at a moderate price, the working of the coal-fields, in a systematic and economical manner, has been much studied, and brought to greater perfection in Britain than in any other country.

Coal, as an inflammable substance, appears to have been known to the ancients, and to the Britons, before the Romans visited this island, it being found so frequently in ravines and beds of rivers, of a colour and texture so decidedly different from the strata which in general accompany it; but as, at that period, and for centuries afterwards, the country was covered with immense forests, which supplied abundance of fuel for every purpose of life, there was no necessity for using coal as fuel.

The working of coal, therefore, only became an object of attention as population and civilization advanced, when agriculture began to be studied, the woods cleared away, and the arts of civil life cultivated; accordingly we find, that the working of coal in Britain, as an article of commerce, is comparatively of modern date, and appears to have commenced about the end of the 12th century. The first charter, giving liberty to the town of Newcastle-upon-Tyne to dig coal, was granted by Henry III. anno 1239; it was then denominated *Sea-coal*, on account of its being shipped for places at a distance. In the year 1281, the Newcastle coal-trade had become so extensive and important that laws were enacted for its regulation.

In Scotland, coals began to be wrought much about the same time; and a charter was granted in the year 1291, in favour of the abbot and convent of Dunfermline in the county of Fife, giving the right of digging coals in the lands of Pittencrief, adjoining the convent. From this period the working of coal gradually increased, though on a very limited scale, until the beginning of the last century, when the steam-engine was brought forward by Newcomen in the year 1705, and was applied to collieries in the vicinity of Newcastle about the year 1715. This machine produced a new era in the mining concerns of Great Britain, and, as it were in an instant, put every coal-field within the grasp of its owner. Collieries were opened in every quarter; and the coal trade rapidly extended to an astonishing scale. This extension of the trade was greatly aided by the genius of the late James Watt, Esq. of Glasgow, whose philosophic mind made the most brilliant discoveries, and so very much improved the principles and power of the steam-engine, as to render it one of the most complete and must useful pieces of mechanism. To Newcomen and Watt the mining interest of Great Britain is highly indebted; to the latter, the empire owes its great rise and improvement as a manufacturing country.

The collieries of Great Britain are now upon the most extensive scale, and are of the first importance to the kingdom; both as regarding its political and commercial interests; so much so, that it is evident, without cheap coal, the manufactories of Great Britain could not be brought forward in competition with those of the other nations of the world, where manual labour is comparatively very low; in short, the coal-mines of Great Britain form a physical and prominent point in the political state of the empire. The capitals employed in the collieries, and in the shipping connected with them, are immense, amounting to many millions. A very considerable proportion of the population of the kingdom is employed in the mines and coal trade, while the ships which carry coals coastwise, are a nursery for thousands of the most intrepid seamen which are to be found in the world.

It cannot easily be estimated what is the total produce of coals in Britain, but it must extend to many millions of tons; for it is known that the output of coal upon the rivers Tyne and Wear, in the counties of Northumberland and Durham, amounts to three millions of tons annually, of which only a small quantity is used in the district, the greater part being shipped coastwise. In these two districts alone, it is estimated that 70,000 people are employed in the coal trade, and that the capital invested in the collieries and shipping is above two millions and a half of money.

With regard to the formation of coal, many theories have been brought forward; but although these display no common share of genius and patient investigation, they have hitherto led to nothing conclusive or satisfactory on the subject. The object in this treatise is, to give a distinct view of the geological situation of coal fields, their absolute forms, the dislocations and troubles which occur in them, and the method of working coal mines.

The great coal-field of Britain, which is composed of numerous subordinate coal-fields, crosses the island in a diagonal direction, the south boundary line extending from near the mouth of the river Humber, upon the east coast of England, to the south part of the Bristol channel on the west coast; and the north boundary line extending from the south side of the river Tay in Scotland, westward, by the south side of the Ochil mountains, to near Dumbarton, upon the river Clyde; within these boundary lines North and South Wales are included. This area is about 260 miles in length, and, on an average, about 150 miles in breadth. Within these bounds all the chief coal-fields are found upon which collieries have been established in Britain; and no coal-field of any consequence has been found, either to the north or south of the lines above mentioned, excepting some small patches of thin coals of inferior quality, and the coal field of Brora in Sutherlandshire, Scotland, which is far disjoined from any other coal-field.

When we take a cursory view of this globe of earth, composed of high, wild, and rocky mountains, its numerous valleys, rivers, and undulated surface, together with the vast expanse of ocean, we are apt to consider the mountains and rocks as forming a kind of chaos, without regularity or order; but the laborious and patient investigations of mineralogists have shown, that there is in the arrangement of the various rocks, an order and regularity beyond what was, or is, commonly imagined,—a regularity, perfectly consistent with that Infinite wisdom and Almighty power which formed the vast, the unbounded system of the universe. It is this regularity in the succession and arrangement of the various rocks, from the Alpine heights to the valleys and level of the sea, which guides the mineralogist in his investigations, when searching for those minerals which are so beneficial to man in his state of civilized society.

Mineralogists have divided the rocks which compose the globe into four classes, viz.

1. Primitive Rocks.
2. Secondary, or Transition Rocks.
3. Floetz, or Newer Secondary Rocks.
4. Newest Floetz Trap Rocks.

In the primitive class of rocks, granite, which generally forms the highest parts of mountain ranges, is reckoned by mineralogists to be the lowest series of rocks, and upon which all the other rocks rest.

It is worthy of particular remark, that the four classes of rocks before mentioned, lie in regular succession, the primitive rocks being the lower series, and the newest floetz trap rocks being the last in succession; and although the rocks composing each of the four classes may alternate variously with each other, yet the order of the four classes has never been found inverted; that is, the primitive and secondary rocks have never been found overlaying the other two classes of what are termed newer floetz rocks.

Beds of coal have not hitherto been found in the primitive or transition class of rocks, but they are found in great abundance in the third class, termed the floetz or newer secondary rocks. Coals are also found in the newest floetz trap formation; but the coal-fields are not extensive, though they are sometimes of uncommon thickness.

One striking and discriminating mark in these rocks is, that in the primitive class not a vestige of organic remains is to be found, and very few in the secondary rocks, whereas the strata which compose the coal-fields abound with innumerable impressions and forms, both of animals and vegetables: The whole arrangement of the strata of the coal-fields exhibits a structure and form most distinctly differing from the other classes of rocks, and, therefore, has been with much propriety termed by the celebrated Werner, *The Independent Coal Formation.*

The strata or rocks which accompany coal are chiefly as follows:

1. Sandstone of various hardness and colour, viz. shades of white, grey, and light red.
2. Slate-Clay.
3. Bituminous shale.
4. Indurated argillaceous earth or fire-clay.
5. Argillaceous ironstone.
6. Greenstone.

Although the independent coal-formation occupies a great area of Britain, as before mentioned, its continuity is frequently interrupted by mountain ranges and rock formations of very considerable extent, where no coal is to be found; and even in those districts where there are valuable fields of coal found, the beds of coal do not in general extend over a great district of country, without being interrupted by what is commonly termed troubles, or more properly dikes and slips; hence the difficulties which occur in working coals, and the caution requisite in searching a district for them.

The beds which compose the first and second class of rocks generally lie in a situation forming a great angle with the horizon, being in many cases nearly vertical, whereas the strata composing the coal-formation are commonly found forming a small angle of elevation with the horizon, although there are instances of their being absolutely vertical.

In some coal fields there is only found one bed of coal, and in others a very great number, varying in thickness from an inch to many feet; it must, however, be remarked, that those beds of coal which are very thick, have generally thin beds of stone running through them in a horizontal position, forming a number of snbordinate beds of coal, lying very close to one another, having, however, the appearance of one thick bed of coal.

In order to exhibit in a clear and distinct view, the various strata connected with beds of coal, the thickness of the coals, and alternations of the strata betwixt them, the following sections are examples, taken from the chief coal-fields in England and Scotland.

SECTION *of the Coal Strata in the Vicinity of* NEWCASTLE.

No.	Names of the Strata.	Yards.	Feet.	In.
1.	Alluvial cover	10	0	0
2	Brown sandstone	24	0	0
3.	*Coal*	0	0	6
4.	Slate clay	5	2	0
	Carry forward,	39	2	6

No.	Names of the Strata.	Yards.	Feet.	In.
	Brought forward,	39	2	6
5.	White slatey sandstone	4	1	0
6.	*Coal*	0	0	8
7.	Grey sandstone	12	0	0
8.	Soft slate-clay	10	0	0
9.	*Coal*	0	0	6
10.	Hard white slatey sandstone	6	0	0
11.	Hard sandstone	9	2	6
12.	*Coal*	0	1	0
13.	Soft fire-clay	3	2	0
14.	Slatey sandstone	7	2	0
15.	*Coal*	0	0	6
16.	Dark slate-clay	7	1	0
17.	*Coal*	0	0	8
18.	Hard white sandstone	3	0	0
19.	Grey sandstone	3	1	0
20.	*Coal*	0	0	8
21.	Hard grey sandstone	8	1	0
22.	Grey slatey sandstone	6	1	0
23.	Dark slate-clay	4	2	0
24.	*Coal*	0	1	0
25.	Grey sandstone	4	0	0
26.	Hard white sandstone	12	0	0
27.	Dark slatey sandstone	6	0	0
28.	*Coal*	2	0	0
29.	Grey sandstone	9	0	0
30.	Slatey sandstone	0	2	0
31.	Slate-clay	1	1	0
32.	Slatey sandstone	0	1	2
33.	Slate-clay	10	0	0
34.	Sandstone	0	1	0
35.	Slate-clay	6	0	0
36.	Slate-clay, with bands of hard sandstone	0	1	6
37.	Hard white sandstone	7	0	0
38	Brown sandstone	0	0	7
39.	Slate-clay, with bands of grey sandstone	4	2	0
40.	*Coal*	1	0	0
41.	Slate-clay	6	0	3
42.	White sandstone	1	1	0
43.	*Coal*	0	0	6
44.	Hard slatey sandstone	4	0	6
45.	Hard white sandstone	2	2	0
46.	Slate-clay	2	2	7
47.	Slatey sandstone	5	1	5
48.	Slate clay, with bands of sandstone	3	1	3
49	*Coal*	0	1	6
50.	Slate--clay	1	0	8
51.	White sandstone	4	0	7
52.	Hard white sandstone	4	0	0
53.	White sandstone	2	2	0
54	Slate-clay, with thin bands of coal	0	2	2
55.	Grey slatey sandstone	4	2	0
56.	Hard white sandstone	8	2	1
57.	*Coal*	1	0	3
58.	Dark grey sandstone	1	0	6
59.	Grey slatey sandstone	6	1	10
60.	White sandstone	1	0	0
61.	*Coal*	1	0	2
62.	Slate-clay	1	1	0
63.	*Coal*	0	0	9
64	Slate-clay	4	0	0
65.	White sandstone	1	1	6
66	Grey sandstone	2	0	6
67.	Grey slatey sandstone	2	0	9
68.	*Coal*	2	0	6
		170	1	6

The preceding section contains sixteen beds of coal, of various thickness, amount'ng to thirty feet two inches, many of which are unworkable. The quality is of the rich caking kind, such as the Newcastle coals in general are; they are soft in their texture, break into very small pieces, and abound much with inflammable air.

In the sections which have been formerly made of the Newcastle coal-field, the term *Whin* is applied to many of the strata; these strata, so named, are, however, not *Whin*, but are sandstones of the hardest kind. This misapplication of the name *Whin*, (or Greenstone) has led mineralogists to wrong conclusions as to the coal formation of that district.

SECTION *of the Coal Strata in the Great Coal-field of* STAFFORDSHIRE.

No.	Names of the Strata.	Yards.	Feet.	In.
1.	Alluvial cover	12	1	2
2.	Sandstone	4	1	0
3.	*Coal*	3	1	0
4.	Bituminous stone	0	0	6
5.	*Coal*	1	2	0
6.	Bituminous stone	0	0	4
7	*Coal*	1	2	6
8.	Bituminous stone	0	0	3
9.	*Coal*, with thin bands of stone	4	1	0
10	Fire-clay	1	2	0
11	Slate-clay	3	1	3
12.	Bituminous shale	0	1	0
13.	Fire-clay, with iron-stone	5	0	6
14	*Coal*	0	2	3
15.	Fire-clay	2	0	0
16.	Slate-clay	1	1	3
17.	Sandstone	7	0	0
18.	*Coal*	1	1	0
19.	Sandstone	2	2	0
20.	Hard sandstone	3	1	0
21.	Slate-clay	1	2	0
22.	Slate-clay, with ironstone	1	1	0
23.	Black indurated clay	3	1	6
24	Slate-clay, with ironstone	3	0	0
25.	*Coal*	1	0	8
26	Fire-clay	1	1	3
27.	Indurated clay	1	1	3
28.	Grey sandstone	9	0	0
29.	Slatey sandstone	2	2	0
30	White sandstone	5	0	0
31	*Coal*	2	1	0
32.	Bituminous stone	0	2	0
33.	*Coal*	2	0	0
34.	Bituminous stone	0	0	10
35	*Coal*	0	2	10
36.	Fire clay	1	2	0
37.	*Coal*	0	2	0
38.	Slate-clay, with ironstone	0	2	0
39	Indurated clay	0	1	6
40.	Slate-clay, with ironstone	3	2	0
41	Slate-clay	1	0	0
42.	Indurated clay, with ironstone	0	2	10
43.	Indurated clay	0	1	6
44.	*Coal*	0	1	6
45.	Bituminous stone	0	0	4
46.	*Coal*	2	0	6
47.	Indurated clay, or fire-clay	0	2	6
		107	0	0

The preceding section contains thirteen beds of coal, of various thickness, amounting to 69 feet 3 inches. The first four coals constitute a thickness of 33 feet; these are wrought as one bed, under the name of the ten yard coal; they are of open burning quality, break into large quadrangular pieces, abound with inflammable air, and are very liable to spontaneous ignition.

Indurated and fire clay predominate in the stratification; but the precise systematic names are not easily applied from the descriptions received. The names given to the coal strata in Staffordshire are very uncommon, and altogether local. These provincial terms are so various, that they present a great difficulty in comparing the strata of one district with another.

SECTION *of the Coal Strata in the County of* CLACKMANNAN.

No.	Names of the Strata.	Yards.	Feet.	In.
1.	Soil	1	1	0
2.	Red sandstone	22	2	4
3.	Slate-clay	1	1	9
4.	Argillaceous ironstone	0	0	3
5.	Slate-clay, with grey slatey sandstone	2	2	2
6.	*Coal-cubical*	0	1	6
7.	Fire-clay, with bands of sandstone	1	1	0
8.	Hard white sandstone	1	2	2
9.	Grey sandstone	1	1	4
10.	Slate-clay	2	0	5
11.	*Coal-cubical*	0	1	8
12.	Fire-clay	0	1	0
13.	Hard white sandstone	5	0	0
14.	Grey slatey sandstone	4	0	3
15	*Coal-cubical*	0	2	0
16.	Fire-clay	0	2	5
17	Hard white sandstone	3	0	3
18	Grey slatey sandstone	2	0	5
19.	Slate-clay, with ironstone	2	0	4
20.	Hard grey sandstone	3	0	4
21.	*Coal-cubical*	0	0	2
22	Fire-clay, with ironstone	3	0	8
23.	*Coal-cubical*	1	0	6
24	Fire-clay	3	1	0
25.	Argillaceous ironstone	0	0	3
26	Grey slatey sandstone	4	0	0
27	Hard white sandstone	9	2	0
28.	Slate-clay	2	0	0
29	Grey slatey sandstone	2	0	0
30	Fire clay	3	0	0
31.	Slate-clay	1	0	0
32	*Coal-cubical*	1	0	0
33.	Fire-clay	0	1	6
34	Grey sandstone	1	2	0
35	Grey sandstone	4	0	0
36.	White sandstone	1	0	9
37.	Slate-clay	0	2	0
38.	*Coal-splint*	1	2	2
39.	Fire clay	0	0	9
40.	*Coal-cubical*	1	0	1
41.	Fire-clay	8	0	4
42	Grey sandstone with ironstone	1	1	7
43.	*Coal-cubical*	0	2	0
44	Fire-clay	0	0	2
45	*Coal-cubical*	0	2	2
46	Grey sandstone	2	2	10
47.	Red sandstone	0	1	0
48	Grey sandstone	3	0	0
49	*Coal-cubical*	0	2	0
50.	Fire-clay	0	1	1
51	White sandstone	1	0	0
52	*Coal-cubical*	0	1	11
53	Fire-clay	0	1	5
54.	Grey slatey sandstone	2	1	4
55	*Coal-cubical*	0	0	5
56	Fire-clay	0	1	8
57	White sandstone	2	0	0
58.	Slate-clay, with ironstone	0	2	5
59	Bituminous shale, with ironstone	0	0	8
60.	*Coal-splint* and *cubical*	3	0	0
61	Fire-clay	0	2	11
62.	Grey slatey sandstone	9	1	6
63	Slate-clay	0	1	6
64	*Coal-cubical*	0	2	8
65.	Fire-clay	0	2	4
66	Red slate-clay	0	1	5
67.	*Coal*, mixed with stone	0	0	5
68	Fire-clay	1	0	3
69.	White sandstone	0	1	0
70	Grey slatey sandstone	0	2	3
71.	White sandstone	0	1	1
72.	Slate-clay	0	1	8
73.	*Coal-cubical*	0	1	4
	Carry forward,	145	1	9

No.	Names of the Strata.	Yards.	Feet.	In.
	Brought forward,	145	1	9
74.	Fire-clay	1	1	7
75,	Red sandstone	3	1	3
76.	Very hard red sandstone	0	2	11
77.	Slate-clay, with ironstone	3	2	7
78	*Coal-cubical*	0	0	6
79	Fire-clay	1	1	10
80.	Grey slatey and sandstone	5	0	9
81	Grey sandstone, with hard bands	1	2	5
82.	White sandstone, with *coal* veins	2	1	10
83.	Red slate-clay	4	1	7
84.	Red sandstone, with a bed uncommonly hard	3	1	9
85.	Red slate-clay	2	2	9
86.	*Coal-cubical*	0	1	7
87	White sandstone	0	0	11
88	Slate-clay	0	1	3
89.	Fire-clay	1	1	3
90.	White sandstone	0	1	2
91	Slate-clay	0	1	3
92	Argillacenus ironstone	0	0	7
93.	Slate-clay	1	2	6
94.	Fire-clay	2	1	7
95.	Slate-clay, with *Coal*	0	2	3
96.	Slate-clay	1	1	1
97	White slatey sandstone	0	1	10
98.	Grey slatey sandstone	0	1	0
99	Slate-clay	0	1	5
100.	*Coal-cubical*	0	1	5
101.	Fire-clay	2	1	9
102	Grey slatey sandstone	2	1	8
103.	White sandstone	7	2	4
104.	*Coal-splint* and *cubical*	1	2	3
105	Slate-clay, with bands of sandstone	2	2	0
106	Slate clay	0	1	10
107.	Hard white sandstone	0	0	7
108.	Slate-clay, with bands of sandstone	0	1	11
109.	*Coal-splint*	0	2	9
110	Fire-clay	0	1	6
111.	Slate-clay	0	2	5
112	Hard white sandstone	0	0	5
113.	Slate-clay	0	1	10
114.	White sandstone	0	0	10
115.	Hard white sandstone	0	1	6
116.	Slate-clay, with bands of sandstone	0	0	6
117.	Slate-clay, with coal	0	2	6
118	Fire-clay	1	2	6
119.	Hard sandstone	2	0	3
120.	Slate-clay	0	1	6
121.	Hard white sandstone	0	1	9
122.	Slate-clay	2	0	4
123.	White sandstone	1	2	3
124.	Grey sandstone	0	1	9
125	Slate-clay	0	0	9
126	Grey sandstone	0	1	10
127.	Slate-clay	0	1	2
128.	Grey sandstone	1	0	2
129	Slate-clay	1	0	4
130.	Hard white sandstone	0	0	9
131.	Hard white sandstone	0	2	0
132.	Slate-clay	0	0	11
133.	Hard white sandstone	1	0	10
134.	Slate-clay	1	0	1
135.	*Coal-cubical*	0	2	2
136	Fire-clay	1	1	1
137.	Slate-clay and *Coal*	1	0	8
138.	Fire-clay	1	0	9
139.	Hard grey sandstone	0	0	5
140.	Slate clay, with bands of white sandstone	2	0	11
141.	Grey sandstone	0	1	0
142.	Slate-clay, with bands of sandstone	0	2	5
		237	2	9

In the preceding section there are 24 beds of coal, of various thickness, amounting to 59 feet 4 inches, but many of them are unworkable; all of them are of open burning quality, and break into large quadrangular pieces. They contain no inflammable air, but the carbonic acid gas is very abundant. It will be seen from inspecting the section, that sandstone abounds in the stratification, and that there are several considerable beds of red sandstone. It is necessary to remark, that the red sandstone of the coal-fields is altogether different from what is termed the *Old red sandstone*, in which no coals are supposed to exist. The red sandstone of the coal-fields is of a bluish colour, whereas the other sandstone is of a deep red, and much closer in the grain.

SECTION *of the Coal Strata at* JOHNSTON, *in the County of* RENFREW.

No.	Names of the Strata.	Yards.	Feet.	In.
1.	Greenstone	36	0	0
2.	Sandstone and common indurated clay, alternating in thin bands	8	0	0
3.	Fire-clay, with coarse ironstone	4	0	0
4.	*Coal*	3	1	0
5.	Indurated clay	0	1	0
6.	*Coal*	3	1	0
7.	Indurated clay	0	2	3
8.	*Coal*	3	0	0
9.	Indurated clay	0	1	0
10	*Coal*	9	0	0
11.	Indurated clay	0	1	0
12.	*Coal*	3	1	0
13.	Indurated clay	0	2	3
14	*Coal*	3	0	0
15	Indurated clay	0	1	0
16.	*Coal*	5	2	0
		81	1	6

The above is a very interesting section of a coal-field, which according to *Werner* belongs to the *Newest Floetz trap formation.* The striking peculiarities are,

1*st*, The great body of greenstone of the common crystalized texture, known in Scotland by the name of blue whinstone, found at the surface, and lying above the common coal strata, which are comparatively soft and have little coherence.

2*d*, The vast body of coal lying together, consisting of 10 beds. There are only 7 beds in the section, but the fourth coal is commonly reckoned three beds, and the lower coal two beds, there being a difference in the quality, with thin divisions in some places betwixt them. The whole thickness is 90 feet 2 inches. Some of the coal is of the open burning kind, but the great part is of the close burning quality, similar to the Newcastle coal, and breaks into small pieces. The coal abounds with inflammable air, and is liable to spontaneous ignition. In a great part of this coal-field the coals amount to only one-half of the thickness represented in the section; but in the place where the section is taken, the coals lie as if they had been cut through, and one-half slid over the top of the other. This singular coal-field is very limited in point of extent.

From an inspection of the four preceding sections it will be seen, that although the alternations of the strata are various, they may be referred to two kinds; viz. *sandstone* and *clay* variously modified; the only exception is the *greenstone*. There is no bed of limestone in any of them; this is however one of the strata found in coal-fields, and sometimes forms the roof of a coal. Beds of limestone are generally found in the lowest series of the coal strata of a district.

With regard to coals termed workable or unworkable, this does not depend upon the thickness of a bed of coal, but upon the price obtained for it: so that a coal which is unworkable in one district, on account of its thinness, would be workable to advantage in another.

The greatest depth to which coal strata have been ascertained is 500 fathoms. This has been done in the Newcastle district, but it is not supposed that they go down to an indefinite depth, from the bason shape of coal-fields. It is with reason supposed, that the rocks upon which the Northumberland coal-field rests are a continuation of the metalliferous beds which form mountains towards the county of Cumberland.

No coal-fields of any extent are found to be absolutely flat, although small portions of them may be so; they generally lie with an angle of inclination to the horizon; they are, however, found at every various angle of inclination; viz. from the horizontal to the perpendicular line; but the most common range of inclination is betwixt 3 and 11½ degrees; that is, from a rise of one foot perpendicular in twenty feet horizontal, to one foot perpendicular in five feet horizontal. In coal mining the angle of inclination is seldom mentioned, the common term for the inclination, or dip, being stated as one in five, one in ten, or one in twenty, according to the circumstances of the case. A coal is reckoned very flat, which lies at an inclination of about one in twenty; and a coal is reckoned to have rather a great inclination, or what is termed a quick dip, when it lies at an inclination of about one in four. Coals having an inclination of from one in three, to one in one, are termed half edge coals; and those which have a greater inclination than one in one are denominated edge coals.

As coals with their concomitant strata lie in a conforming situation, and parallel to each other, similar to the leaves of a book, and at an inclination with the horizon, having a cover of earthy alluvial matter in general over them of considerable thickness, each of the strata meets the alluvial cover in the manner as represented, Plate CCCLXXXVIII. Fig. 1. where A is the surface line, B the under part of the alluvial cover C, and *a*, *a*, *a*, coals with their accompanying strata. This alluvial cover is found to be of various thickness, from a few inches to many fathoms; and it is this covering which creates the greatest difficulty in searching for coal and other minerals. It is in mineralogy to the strata which are underneath, what the flesh is to the bones in anatomy, when the covering is removed, the absolute structure is at once seen.

In describing the absolute forms or shapes of coal-fields, it is necessary that the cover of earth above the strata be considered as removed, that every point may be more easily comprehended; and, to render the subject less intricate at first, we shall consider the coal fields as being of a regular shape, and without dislocations.

In general, coal-fields have either the form of a circular or long elliptical bason, or are segments of these figures; so that no extensive field of coal lies as to itself in the same plane, though a small portion of it may appear to be so. There are but few instances of the entire bason form, but this form we shall first explain, in order to lead on to the more intricate varieties which occur. Plate CCCLXXXVIII. Fig. 2. represents the horizontal section of an elliptical coal-field, with the coals A and B rising to the surface in every direction, with their accompanying strata, and dipping to the centre of the bason C. Fig. S. is a section of the bason in the line DE. It is evident from an inspection of the figures that the strata in the line FG (Fig. 2) have a greater dip than the strata in the line DE, because they reach the centre of the bason in a shorter horizontal distance; hence, if the bason were forty times longer than it is broad, the dip of the strata from D to C, and from E to C, would be very flat when compared with the dip from F to C, and from G to C, which would be comparatively great. Here we conceive the bason to be of a regular elliptic form, but we find in general that the transverse line DE does not divide the bason equally, but unequally, as represented in Fig. 4. where it is evident that the dip of the strata from H to C is much greater than the dip from I to C, so that while the coals from C to I are flat, having a moderate rise, the coals from C to H have a great rise, and are frequently of the class of edge coals. A right understanding of these plans and sections will make the other figures of a coal-field and segments of the bason more easily comprehended.

The next form or shape of a coal-field is that which is semi-elliptical, as represented by the horizontal section (Plate CCCLXXXVIII. Fig. 5) where A and B are coals with their accompanying strata, having their line of bearing in the direction C. D, and the line of dip from E to F, these coals are cut off in the line of dip by a natural fissure in the strata C. D; hence, in prosecuting the working of the coals to the dip, they are lost, and in place of coal, nothing but stone, or the strata accompanying coal, are to be found: the nature of this fissure or obstruction will be explained afterwards.

These forms of coal-fields now described, or modifications of these forms, are what we find the most common. There are, however, instances of the inverted bason form, and of inverted segments of it; but these are very rare in comparison with the other. Fig. 6. is the vertical section of this form, A, B, C, represents the coals dipping in every direction to F and G.

The cover of earth which lies above the strata is of two distinct kinds, both of which are alluvial, the one older than the other, viz.

1. The recent alluvial cover.
2. The old alluvial cover.

The recent alluvial cover is found by the sides of rivers and arms of the sea, in general very little elevated above the surface of the waters which evidently formed them.

The old alluvial cover succeeds the recent alluvial cover, is in general more elevated, and extends to the tops of the mountains; there, however, it is found very thin. It is in the intermediate moderately rising ground where it is found of the greatest depth.

The recent alluvial cover we have found to be in some instances nearly 100 feet, and the old alluvial 180 feet in depth, above the rock.

The recent alluvial cover is generally composed of soil, clay, wet sandy loam, sludge, and sometimes beds of peat earth, also beds of gravel; and in digging through it, trunks of large trees and brushwood are frequently found, with beds of sand containing great varieties of sea shells; adjoining the arms of the sea, the remains of marine animals from the largest to the smallest size are also occasionally found. In the alluvial cover, by the sides of quick running rivers in coal districts, pieces of coal and of the accompanying strata abound, but adjoining slow running rivers and arms of the sea, these fragments are seldom to be found, excepting when brought there accidentally.

The old alluvial cover is commonly composed of clay intimately mixed with sand, small rounded stones, and frequently with boulder stones, from a few pounds to several tons in weight; it is quite impervious to water, and is termed *till* by agriculturists. In examining this cover when broken up, it is found to contain fragments of almost all the strata of the adjoining coal-field, such as sandstones, slate-clay, ironstones, and coal, the largest only a few inches in size, the angles sharp, which show they had not suffered by attrition. It is remarkable that no remains of trees or plants are to be found in this earth, nor any remains of marine animals or shells, though immediately adjoining the recent alluvial soil, where they are so abundant. This cover has sometimes beds of sand in it, and at the foot of mountains is mixed with many fragments of the mountain rocks.

As to the general situation of coal-fields with their accompanying strata, they are found,

1. Under the level of the sea.
2. Above the level of the sea, moderately elevated.
3. Considerably elevated above the level of the sea.

Having considered the shape or form of coal-fields as uniform and entire, we have now to describe the dislocations and ruptures of the strata, for it is found in practice, that in place of a regular figure, the bason form is broken, dislocated, and deranged, forming segments of every various form, the dislocations, extending from a quarter of an inch to upwards of 600 feet, in a perpendicular or sloping direction, or separated horizontally from the breadth of an inch to upwards of 100 feet: It is these dislocations, which render the searching for coal, and the operations connected with the working of it, so difficult and intricate, while at the same time they are frequently of the greatest benefit.

The dislocations and obstructions which are found in coal-fields, are known by the names of

1. Dikes.
2. Slips.
3. Hitches.
4. Troubles.

The three first relate to the dislocation of the strata, the fourth, or what is termed troubles, relates to the changes which take place in the bed of coal.

A dike is like a wall of extraneous matter, which divides all the beds of coal found in a coal-field. It varies from a few inches to many fathoms in thickness, and penetrates through the strata to the greatest depth the miner's operations have yet reached; they are composed of,

1. Sandstone.
2 Greenstone.
3. Basalt.
4. Porphyritic clay mixed with white calcareous spar.
5. Heterogeneous mixture of the coal strata.
6 Water gravel.
7. Quicksand.
8. Old alluvial clay.
9. Recent alluvial clay.

The first five in the order may more properly be named dikes. The four last are more commonly known by the name of gaws, gashes, or chasms.

A slip is a fissure in the strata, from the tenth of an inch to two or three feet in width; which fissure is filled with rubbish and fragments of all the strata found in the coal-field. The strata, on one side, are slipped past those on the other side of the fissure, and this dislocation receives the name of a slip, where the coal has slipped off its parallelism fully its own height. These slips are found from the extent of a few feet, to upwards of 600 feet perpendicular.

A nitch is a smaller kind of slip, where the dislocation is from an inch to the extent of the thickness of the coal. In some mining districts, slips and hitches are known by the very appropriate name of steps.

Troubles affect the stratum, or bed of coal, not only as rendering it very difficult to work, but very inferior in quality, and frequently altogether useless as an article of commerce. These troubles are not found in the chief extent of a coal-field, they only affect it partially, and may be classed under the following heads :

1. Stone in irregular beds.
2. Nips.
3. Shaken coal.
4. Foul coal.
5. Pyritaceous, or brassy coal.
6. Sparry coal.
7. Stoney coal.
8. Black coal.
9. Sooty coal.
10. Dike coal ; named,
    a, Burnt coal.
    b, Dander coal.
    c, Humphed backs.
11. Glazed backs.
12. Troubles in the roof and pavement.

The position and effect of these dislocations and troubles have now to be described.

Dikes, as to their longitudinal direction, are found not only stretching in the line of bearing through the coal-field, but in every direction, sometimes for many miles nearly in the same straight line, while other dikes havh irregular deflections, but without sharp angular turns. It seldom occurs that great dikes are numerous in a coal district, but the contrary is frequently the case with dikes of a small size ; they can only be seen in the beds of rivers, or on the sea-shore, but those of greenstone and basalt, from their superior hardness, frequently rise above all the other strata, like a crest or projecting ridge.

Dikes of greenstone, of a few feet to three or four fathoms in thickness, are found sometimes very numerous, even in a very limited extent of coal field, not exceeding the area of 200 acres, lying in various directions, and crossing one another. Fig. 7. Plate CCCLXXXVIII. represents the horizontal section of a coal-field, intersected with greenstone dikes. AB and CD are two dikes lying parallel to each other, EF and GH are cross or oblique dikes, which not only divide the coal strata, but divide and separate the dikes AB and CD. In looking at a horizontal section of a coal-field, the dikes, which intersect it, appear to affect the strata no more than the dividing and separating of them, excepting when greenstone dikes occur, in which case, a change of the coal adjoining them is very evident, as will be noticed afterwards, when the effects of dikes upon the strata in the verticlal section are treated of. But before entering on this subject, the longitudinal direction of slips will be considered.

Slips run in a longitudinal direction through the strata of a coal-field, and in every obliquity to one another. Fig. 8. Plate CCCLXXXVIII. represents a horizontal section of a coal-field, with two slips, AB and CD, in the line of bearing, which throw the strata down to the crop ; this is the simplest form of slips. Fig. 9. represents part of a coal-field intersected with slips somewhat similar to a broken sheet of ice. In this Figure, AB is a dike ; all the other lines and ramifications in the figure are slips of every variety and kind, producing dislocations from the least measurable distance to many fathoms ; the slips at the points marked *a*, *a*, *a*, disappear ; the lines at C represent four slips of a small size, known by the name of hitches.

There does not appear any general law as to the line of direction of these slips, only the ramifications are generally more in a dip and rise direction, than in the line of bearing of the coal-fields.

The effects of dikes and of slips upon the coal strata, when viewed in a vertical section, are more evident than in the horizontal section, where they only appear like walls, veins, and lines of simple separation. Fig. 10. Plate CCCLXXXVIII. is a vertical section of a coal-field from dip to rise, with three strata or beds of coal, *a*, *b*, *c*. AB is a dike at right angles to the plane of the coal strata. This rectangular dike has only the effect of dividing and separating the coals, and all the accompanying strata, but produces no alteration in the line of rise ; but further to the rise, the oblique dike CD interrupts the coals *a*, *b*, *c*, and not only divides and separates them, but throws them and all their accompanying strata greatly lower down ; but though thrown down, as represented in the figure, the coals and strata still keep the same parallelism and direction of rise. Still further to the rise, the oblique dike EF interrupts the coals *a*, *b*, *c*, and not only divides and separates them, but throws them, and all their accompanying strata, greatly up, and produces a much quicker dip and rise, as represented in the figure. Sometimes the coals in the division H, betwixt the dikes C and E, are found nearly horizontal, and the effect of the dike EF is sometimes such as to throw out the coals altogether, so that no vestige of them can be found in the division K. Such are the most prominent changes in the strata, as to their line of direction produced by dikes ; but of these changes there are various modifications.

The effect of slips on the strata is represented in the vertical section, Fig. 11, where *a*, *b*, *c*, are coals with their accompanying strata. AB is a slip which intersects the strata, and throws all the coals of the first compartment very much lower, as represented in the compartment No. 2.; and, from the magnitude of the slip in this instance, it throws in other coals, marked 1, 2, 3, which were not found in the compartment No. 1. CD represents a slip having the same effect, but not to the same extent. EF represents a slip intersecting the strata, but contrary to the former in its position ; the effect of this is, that the coals *a*, *b*, *c*, are thrown up, as represented in the compartment No. 4. Sometimes this slip brings into view coals situated under these marked *a*, *b*, *c*, such as the coals 4, 5 6 ; and when it happens, as we have freequently seen, that a coal marked 4 is directly opposite a well known coal, as *e* in the compartment No 3, the case is difficult and bewildering to the miner. Besides these varieties, we find a number of slips or hitches often very near to one another, as in the compartment No. 5, where the dislocation of each slip is not great, but the amount of the whole forms a considerable slip as to the coals in the compartment No. 6. These are the general effects of dikes and slips in a vertical section of the strata from the dip to the rise; whether these dislocations lie in the line of bearing, or with a moderate angle of obliquity to it, that is under 45 degrees. The effects of dikes and slips, in pursuing a dead level course direction, are exemplified in Fig. 12. Plate CCCLXXXVIII. Where the coals and accompanying strata are of course horizontal, and the dikes and slips, lying at a greater angle than 45° to the line of bearing, they are termed dip and rise dikes, or slips, as AB, CD, EF.

From what has been stated regarding the effects of dikes and slips, as to the dislocation of the strata, independently of any changes produced in the coal and strata adjoining, to be noticed afterwards, those who are employed in conducting the operations of collieries, consider that these dislocations follow a general law, which is this: Let Fig. 1, Plate CCCLXXXIX. represent a stratum, or bed of coal, with the accompanying strata; A, the pavement of the coal, and B the roof; if, in prosecuting the mine, as at C, a dike, D, is met with, which forms with the pavement a right angle, viz. of 90°, it is concluded that the dike only has divided and separated the strata its own thickness, so that when a mine is driven through it, the coal is found directly opposite; but, in the further prosecuting of the mine, if a dike, F, is met with as at E, which forms an obtuse angle with the pavement, that is, an angle greater than 90°, it is concluded that the dike has not only divided and separated the strata its own thickness, but has thrown up the coal and accompanying strata, which, on running a mine through the dike, is found to be the case as at G. Lastly, if a dike H is met with at I, forming an acute angle with the pavement, as in the figure, that is, an angle less than 90 degrees, it is concluded that the dike has not only divided and separated the strata its own thickness, but has thrown down the coal and accompanying strata, which, on running a mine through the dike, is found to be the case, as at K.

The same very useful and important law holds as to slips, with this difference, that when the slip forms an angle of 90° with the pavement, there is a great uncertainty whether the strata on the other side are thrown up or down; and this can only be proved by mining and boring; only it must be remarked, that if, in perforating the slip, the coal is found neither thrown up or down, the occurrence is not a slip, but simply a fissure of the strata.

Dikes and slips are denominated upthrow or downthrow, according to the position in which they are met in working the mine. Thus, in Fig. 10. Plate CCCLXXXVIII. if the miner is advancing to the rise, the dike AB neither throws up nor down. CD is a downthrow dike to the rise of a certain number of fathoms, and EF is an upthrow dike also to the rise. On the contrary, if the dikes are met with in working from the rise to the dip, the names of the dikes, as to being upthrow and downthrow, are exactly reversed; viz. what was an upthrow in the first instance, is a downthrow in the second; and, in meeting the dikes or slips this reverse way, the same law of course holds as to the angle formed by the pavement, and the intersecting line of the dike or slip.

In the same manner, dikes and slips, which run from the dip to the rise direction, are denominated upthrows or downthrows, to the east, to the west, to the south, or to the north, according to the line of bearing of the coal-field, and the direction in which the dikes or slips are met with in the mine; so that a dike or slip which is an upthrow to the east, when pursuing the coal mine eastward, is a downthrow dike or slip, when pursuing the coal mine westward.

Hitches are slips of the strata of a small size, and are so denominated when the slip or dislocation does not exceed the height of the coal; they are frequently very small, even the least part of an inch, yet though of the smallest size, their effects are distinctly visible affecting the coal. Hitches are frequently denominated, very appropriately, *steps* by the miner. Plate CCCLXXXIX. Fig. 2. shews the effect of hitches upon the strata, where the hitches A, B. C, D. E, F, G, H, dislocate the coal and accompanying strata. At A the hitch is the height of the coal, at B it is half the height up, at C and D the effect is less, at E it is nearly the height of the coal, at F the effect is scarcely visible, at G it is down, and at H the coal is again thrown up to the extent of its height. Hitches do not extend generally very far, either in a longitudinal or in a perpendicular direction; for though they may be found in one or two coals in a coal-field, they may not be seen in the the upper or under coals, so that their effects in the coal-field are commonly very limited, when compared with the effects of dikes or of slips.

Troubles.—These affect the stratum or bed of coal, and are of various kinds, as before mentioned, viz.

1st, *Some in irregular beds*.—This trouble sometimes begins as a horizontal division in the coal scarcely visible, gradually increasing in thickness, and that frequently to such a degree as to render the coal altogether unworkable; in a thick bed of coal, a stone of this kind sometimes increases from a line even to several fathoms in thickness, in which case one or other of the portions of the coal thus divided, is either abandoned as unworkable, or each of the two divisions is wrought as a separate and distinct coal. It is to be remarked, that the two portions of coal are together generally equal in thickness to the bed of coal before the stone made its appearance; if however bands of stone or of argillaceous clay are found lying regularly through coals in a coal-field, these are not reckoned troubles.

2d. *Nips*.—This is a very remarkable trouble in coal, and is not very common; it is produced by the roof and pavement of the coal gradually approaching each other, until not a vestage of coal is to be seen. The extent of this trouble is from an area of a few feet to that of many acres. The horizontal form of a nip is very irregular, and when found, no idea can be formed of its extent; it is frequently the case, that if the coal has an argillaceous roof and pavement, these disappear with the coal, and the upper and under harder strata of sandstone are in contact, divided only by a very thin sooty line. Plate CCCLXXXIX. Fig. 3. represents the vertical, and Fig. 4. the horizontal section of a nip.

3d. *Shaken Coal*.—By this trouble the texture of the coal is not only destroyed entirely, but the whole of the coal from roof to pavement is of no use whatever; the roof and pavement generally keep their common parallelism, and no convulsion is to be observed in the adjoining strata. The shaken coal has the appearance of the rubbish of an old coal waste, being a heterogeneous mass of dusty coal, mixed with small cubical pieces of good coal. This shaken coal is so soft, that frequently it can be dug with a spade.

4. *Foul Coal*.—This denomination of trouble is ap-

plied to no specific kind of coal, every coal which is deteriorated in quality, or so mixed with heterogeneous matter as to be useless, or the greater part so, is denominated foul coal.

5. *Pyritaceous Coal*, or the *Brassy Coal* of the miners.—This trouble arises from the coal being so mixed and entwisted with pyrites as to be of no use as coal. It may be remarked, however, that the term pyritaceous coal is not applicable to those coals which have pyrites in them of a lenticular form, and which can with ease be separated from the coals, for these do not deteriorate the quality of the coal as they are picked out.

6. *Sparry Coal.*—This trouble arises from the coal having an increased number of fissures together, and filled with a hard white sparry substance, the sulphate of lime, so that the coal is rendered useless and very difficult to work.

7. *Stoney Coal.*—This trouble arises from the coal becoming very much mixed with stone in an irregular manner. These stones do not lie in regular beds; and they are so intimately joined or connected with the coal, that they cannot be taken out without destroying and breaking to small pieces a great proportion of the coal to which they are attached; on which account such stoney coals have frequently to be sent to market with the stone in them, which is greatly against their sale. Coals having regular bands of stone in them, and which are easily separated, do not come under the denomination of stoney coals.

8. *Black Coal.*—This is a trouble which rather affects the appearance than the absolute quality of the coal; it generally occurs suddenly, that is, while in one part of the coal-field the coals have the common bright fracture, a slip or hitch of very trifling magnitude will produce on the other side coals termed black coal. The appearance is dull, without the least lustre. It is equally compact in texture as the other coals of the field, and burns well. This trouble, however, greatly reduces the value of the coal at market, its appearance being so very much against it.

9. *Sooty Coal.*—This trouble renders the coal of a dead, sooty, friable appearance, and of no use, is never of great extent, nor does it appear to have arisen from any convulsion of the immediately adjoining strata, as the roof and pavement where it occurs keep their parallelism with each other. This trouble is, however, generally found when approaching some considerable dislocation of the strata, such as a slip or dike.

10. *Dike Coal*, named also *Burnt Coal*, *Dander Coal*, or *Humphed Coal*, are all names applied to the same kind of trouble in the bed of coal. The particular names above mentioned are applied by the common workmen and miners, the name dander signifying *scoria*. The appellation humphed is a provincial term, and only used amongst miners, signifying the same thing as burnt or dander coal. This kind of trouble is in general found to exist on both sides of dikes composed of greenstone, basalt, or prophyretic clay; the trouble beginning at a distance from the dike on both sides, the coal at first by degrees losing its bright fracture and becoming *black coal*, then burnt or dander coal, which next the dike appears run into a tortuous mass, with irregular cellular cavities, and is more of the nature of a dull, black, stoney matter, than any thing connected with coal. Coal found in this kind of trouble has none of the qualities of glance coal, the blind coal of Scotland, or the stone coal of Wales; for, although placed in a heap, they will not kindle though fire is applied, they will grow red hot, but instantly cool, as stones would do when heated and the fire withdrawn. Some pieces are found occasionally of the purest kind of glance coal, with a very bright metallic lustre, and so hard as to be with difficulty scratched with a knife; such coal is divided by numerous small veins of a white sparry substance. This kind of trouble, besides being found adjoining dikes of the above description, is found occupying considerable districts of a coal-field; and though no change is observed in either the roof or pavement, the coal is completely useless, and will not burn though fire is applied to it. It is, however, in general different in appearance from the coal found adjoining dikes as before mentioned, in as much as more of the stratified texture remains, and is not run into a tortuous mass with irregular cavities. It has been asserted by some miners, that this change is occasioned by greenstone or basalt being near the coal, either above or below it. This we presume remains to be proved.

The term burnt coal is not known amongst mineralogists, or rather is not admitted; the name is applied by the unlettered miner, from the simple ideas rising in his own mind, being altogether a stranger to those theories which so warmly interest and so much divide the philosophic world. It must be particularly remarked here, that when a coal-field is working of the common coal, it is sometimes gradually changed into a species of glance-coal, which burns of itself, when ignited, and is used for economical purposes, has no smoke, and only a blue flame, with intense heat. This is not reckoned one of the species of the burnt coal of the miner, but is simply one of those changes in quality incident to coal.

11. *Glazed Backs*, *Lips*, or *Leips.*—This is a trouble in the coal more generally found in an oblique direction as to roof and pavement, seldom perpendicular; they are also more frequently found lying in the line of bearing, than in a crop and dip direction, and are distinctly different from the natural divisions found in coal. Although there can scarcely be perceived any slip in the roof, it is evidently a slip of the very least degree which occasions this trouble. Both sides of the fissure are smooth and glossy, and the coals thus divided have no tenacity, which renders this trouble dangerous to the miner by the coal falling suddenly forward without warning. A single fissure of this kind can scarcely be called a trouble, but when many of these are near to one another, the coal is injured, and the roof rendered very dangerous.

12. *Troubles in the roof and pavement of the Coal.*—These troubles are more generally found when approaching a dislocation of the strata, though they are occasionally found in other parts of the coal-field. They affect the roof with narrow pendent ridges of stone or protuberances, at times very close together, in other instances like long inverted waves. The troubles in the pavement are generally sudden wave-like swellings. These troubles frequently affect the coal very much, rendering it sometimes not only firmer in the texture, but uncommonly hard; at other times the coal adjoining them is soft, and so deteriorated as to be altogether useless.

Besides these troubles, there is frequently another kind found in the roof, of a very singular form, known by the name of a *pot bottom*, or *cauldron bottom*; they are from the size of a few inches to five feet in diameter. One of these is represented in Plate CCCLXXXIX. Fig. 5. In working the coal, the miner generally knows that he is approaching one of these by the coal becoming harder and more twisted in its texture, and this continues till the trouble in the roof is passed. The general form is similar to that represented in Fig. 5. *a* is the bed of coal, *b* the pot bottom, having an irregular and rough inverted mouth of stone, *d* is coal generally from half an inch to an inch thick, altogether different in texture and appearance from the bed of coal, with which it is connected, being of a bright pitchy lustre, and breaks into very small pieces; sometimes it is of the nature of glance coal. The stone *b* which fills the inverted pot is frequently of the same kind of stone which composes the roof, but more frequently is an argillaceous stone, of the nature of good fire-clay. The sides of the pot bottom at *d* are generally as smooth as glass and furrowed in the vertical direction, so that there is no tenacity where the sides of the pot bottom join the roof; this circumstance renders these troubles very dangerous, particularly when of a large size. The peculiar singularity attending this trouble, is the uniform twisted texture and alteration which are found in the coal immediately under it, without any mixture of the stone which composes the pot bottom.

The Roofs of coal are formed of all varieties of the coal strata, as may be seen from the examples of stratification in the preceding part of this treatise. As roofs they are of various quality, from good to very bad; a roof is reckoned good which keeps entire, not only while the coal is working, but for a considerable time after. Sometimes a stratum of roof stone next the coal comes down along with the coal while working, named a *following*, leaving a firm roof-stone above; at other times a stratum or two of the roof-stone have to be taken down shortly after the coal is wrought: this is also termed a *following*; and while the miner works under it, he supports it by prop-wood for his own safety; but these are not reckoned dangerous roofs.

A bad roof is that, which, having little tenacity in itself, cannot be kept up either in boards, rooms, or in narrow mines, even by the aid of prop-wood; it has, therefore, to fall in the waste, care being taken to keep it up along the wall-faces; and the iron rail-roads are in some bad roofs laid upon the top of the fallen strata. The roofs which are most dangerous to the workman are those where the roof stratum is thick, with many open cutters in it, or where there are irregular beds, thick in the middle and wedge-shaped towards the edges. These roofs give no warning before they fall, by which the danger is much increased. The ordinary way in which a miner tries the roof to be safe or not, is to strike it gently with the side of his pick; if the sound produced is sharp and clear, he concludes that the roof is good, but if the sound is obtuse and hollow, he is certain that the roof is bad and dangerous. He may, however, be deceived in trying a roof composed of a thick stratum, as it will produce a clear sound, though ready to fall, owing to the cutters with which it is intersected.

Having stated the effects of dykes, slips, and hitches, as to the dislocation of the strata, the changes produced by them upon the coals and strata adjoining have now to be noticed.

When coals approach dykes composed of sand-stone, heterogeneous mixture of stones, water, gravel, quick-sand, or clay, we seldom find any great change in the composition of the coal, excepting that it is either rendered a little softer or harder, with the natural fissures occasionally very open, and filled with sulphate of lime and pyrites, or with sand or clay when close to dikes of this composition. The strata adjoining are in some cases rendered flatter than in the general coal-field; in other cases the dip and rise are greatly increased, and the line of level frequently altered. We have, however, to notice a very remarkable and decided change in the stratum or bed of coal, as it approaches dikes composed of greenstone, basalt, or porphyritic clay, dikes of greenstone or of basaltic rock, (the common blue whinstone of Scotland,) are much more common in the coal-field of Scotland than the porphyry dikes; and their effects are well known, as they are frequently met with in several of the mining districts. The first indication perceived in approaching one of these dikes, is, that the coal begins to lose its common brightness in the fracture, and assumes a dull black appearance, but still retains its common qualities of good burning coal, with very little difference; but every foot of advance towards the dike the coal becomes worse, loses every appearance of common coal and all its qualities; the texture of the coal is lost, and the whole stratum of it becomes a mass of black stoney matter, as before described, when treating of troubles appertaining the bed of coal, under head No. 10. *Dike Coal.* Adjoining to the dike, the cavities of this coal are sometimes filled with a soft yellowish clay, having an unctuous feel; this clay is also sometimes found in the fissure betwixt the coal and the face of the dike, when the dike is cut through. The coal on the other side is found exactly changed as in the approach to the dike before mentioned, viz. hard, stoney, and cellular next the dyke, and these qualities gradually disappearing till the coal assumes its common lustre, with all the qualities of good coal, as found before the deteriorating symptoms appeared on approaching the dike.

When coals approach slips, a variety of changes are found, and they are very seldom met without symptoms appearing of their approach, particularly if they are of considerable magnitude. The most common symptoms of their approach are, numerous hitches, swellings in the roof, sudden risings or wavings of the pavement, the coal much stronger in its texture than common, and more difficult to work; at other times much softer than usual, and this softness at times increases to such a degree as to lose all firmness of texture. In this state it is sometimes like coal dust mixed with small cubical pieces of good coal; at other times it is found uncommonly friable, somewhat like soot. The occurrence of iron pyrites is very common, in some instances filling fissures and cavities, having a beautiful golden lustre, and crystallized, some of the crystals forming cubes of more than half an inch in size, and finely laminated; in other instances, the pyrites are so run into and entwisted with the coal as to form a very heavy mass of singular texture. We also find the sulphate of lime very abundant near to slips, filling up the numerous fissures of the coal, and entwisted with it coals of the soft and of the sooty quality above mentioned; where the pyrites and sulphate of lime abound, the coals are of no use as fuel. An increase of water from the fissures, as a dike or slip is approached, is also common; and when the slip is found, very great feeders of water sometimes occur. If the coal is dry, inflammable air (if found generally in the coal field) comes off in great quantity; and there are instances of inflammable air being found at a dike or slip, though never seen before in the district.

Sand-dikes, or gashes containing quick sand, are dangerous from the quantity of water they contain, which is found in some instances so great as to drown and destroy the colliery, if not prevented by powerful means.

We have now to describe the general effect produced upon the coals and accompanying strata by dikes and slips, in order to shew how coals wave, or are spread over a great district of country; and this is essentially necessary before attempting to describe the modes which have been adopted in searching and boring for coal.

Although, as before mentioned, there are instances of coal-fields of a circular bason form, and more commonly of a long elliptical shape, yet there are few instances, comparatively, of this entire form, either in the right or inverted position; yet we reckon that the entire bason form is the true and complete form of a coal-field, and that the general form of coal-fields are portions of this bason shape, produced by the natural effects of dikes and slips, of which the following detail, with the corresponding figures, Plate CCCLXXXIX. will elucidate. Fig. 6. represents a horizontal section or plan of a coal-field, as found immediately under the alluvial cover. Only two beds of coal are represented in this example, that the subject may be rendered as little complex as possible, and, therefore, whatever changes in position, and whatever dislocations take place in the coals, take place also in all the accompanying strata, at least this may be admitted in a general point of view. The area in the figure is supposed to contain a space of 64 square miles, viz. a square of 8 miles on the side. The coal district is bounded by transition rocks on the north, more elevated than the coal district. A, is an elliptical bason-shaped coal-field, where the coals *a*, *b*, dip inwardly, as represented by the points of the arrows, but they dip much quicker next the transition rocks, as they then conform with the dip of these; and though the coals are the same distance from each other in every part of the bason, when measured at right angles to the pavement, they appear in the horizontal section much closer upon the north than on the south side of the bason. This apparent difference depends entirely upon the angle of inclination which the coals make in particular positions with the horizon, as will be shewn distinctly in the vertical section. Upon the south of the coal-field A, the slip B is found dislocating the strata, throwing the coals down from the surface 140 yards to the south, and forming the coal-field C, where the same coals of the coal-field A are found again, having the same parallelism of dip. The slip D is found upon the south of the coal-field C, dislocating the strata, and throwing the coals down from the surface 100 yards to the south, and forming the coal-field E, where the coals of the coal-field C are also found. The slip F is found dislocating the strata, and throws the coals down 210 yards, and forms the coal-field G in the same manner as the former coal-fields, as represented by the coals *a*, *b*. The coal-field G, in place of a slip to the south of it, takes, as it is termed, a counter dip, occasioned by a ridge in the strata of a saddle shape, beyond which ridge the same coals form with a contrary dip, as represented by the arrows, and form the coal-field H. In this manner coal-fields are found stretching over a district of country in a crop and dip direction, somewhat similar to what is represented in the Figure, but with many varieties arising from the obliquity of the slips to each other. This spreading out of the coal-fields in the crop and dip direction is produced by slips generally lying, not parallel, but somewhat in the direction of the line of bearing, and by ridges and counter dips lying in the same direction. Besides the coals *a*, *b*, inserted in the Figure, as an example, all the coals, above and below these, with their accompanying strata, suffer the same alteration as before mentioned.

While these slips and dislocations lying nearly in the line of the bearing of the coal have the effect of throwing the coals over a district of country in the line of dip and rise, the dikes, slips, and dislocations which lie in an oblique direction to the former, such as the slips marked K in the Figure, have the effect of stretching or extending the coal-field over the country in the line of bearing. The lines marked L, are dikes which only separate the strata the thickness of the dike, without throwing the coals and the accompanying strata either up or down. It will be seen from the Figure that the oblique dislocations, when they throw the strata down, and the same parallelism of dip remains unaltered, that the crops extend to a greater distance before they meet the alluvial cover; and, on the contrary, when the slip is an upthrow, the crops of the coals and accompanying strata are diminished in breadth by coming sooner in contact with the alluvial cover. K *c*, is a slip down to the east, forming the coal-field M. K *d* is a slip down to the west, forming the coal-field N. K *e* is a slip up to the west, which cuts off the coal-field N in that direction. K *f* is an upthrow slip to the east, which has the effect of throwing back the crops of the strata. K *g* is a downthrow slip to the west, which has the effect of throwing forward the crops of the coals and strata. K *h* and K *i* being downthrow slips to the west, have the same effect as in the last instance. K *k* being an upthrow slip to the west, has the effect of throwing back the coals and accompanying strata. In this manner coal-fields are extended over a district of country in the line of bearing, in every variety of change, according to the line of obliquity in which the slips occur with regard to the line of bearing, and the extent of the dislocation, as to the magnitude of the slip. These of course frequently change the direction of the line of level at times to the extent of 90°, as must be obvious from inspecting the Figures; because, generally, the line of level is a line parallel to the crop, that is, parallel to the line of the coals where they intersect the plane of the alluvial cover, which will be more particularly exemplified when the working of coal is treated of.

The next point of consideration is the vertical section of the coal-fields before exemplified. Such sections are generally made in the line of dip and rise, on which account the section, Fig. 7. is in the direction of the dotted line OP, Fig. 6. and the coal-fields, beds of coal, slips, counter dips, and crops, are marked with the same letters as in the horizontal section, which exemplifies the positions noticed in the horizontal section. These sections are to be considered only as diagrams, shewing within a very limited space the phenomena connected with coal-fields, it being impossible to shew the several parts in equal proportions to one another, as the sections represent miles in extent, whereas coals are only a few feet in thickness, and the distance between them a few fathoms. In order, however, to shew the effect of a great slip upon a scale of proportion, Fig. 8. represents three coals *a*, *b*, *c*, rising southward 1 in 5; the coal *b* is

15 fathoms distant from the coal c, and the coal a is 10 fathoms distant from the coal b; the coals a and b crop out at the line of junction with the alluvial cover, but the coal c is cut off by the slip AB down to the south, forming the south coal-field, where the coals a, b, c, are found dislocated and slipped down. The magnitude of this dislocation is measured by the taking the distance betwixt the pavements of any of the coals in the north and south fields, measured along the face of the slip, which in this instance is 50 fathoms. It will also be observed, from this figure, that though the distance betwixt the coals a and b is only 10 fathoms perpendicular, yet their distance, when they crop out, is 50 fathoms in a horizontal line; and the distance betwixt the coals b and c being 15 fathoms, their distance, when they crop out, is 75 fathoms. It follows of course, that those coals which have a great dip, or make a great angle with the horizon, have the less difference betwixt their perpendicular distance from each other, and their distance from the one crop to the other, where they meet the alluvial cover, whereas those coals which lie comparatively very flat, or at a small angle with the horizon, have a very great difference betwixt their perpendicular distance from each other, and their distance where they crop out or meet the alluvial cover, as may be seen by inspecting the figure. The proportion betwixt these is found by multiplying the perpendicular distance by what is termed the rise: thus, if the distance betwixt two coals is ten fathoms, and the dip 1 in 5, then 10×5 gives 50 fathoms for the distance in the horizontal section at the crop, or if the horizontal distance and dip are known, then the horizontal distance divided by the dip gives the perpendicular distance betwixt the two coals, viz 50 divided by 5 gives ten fathoms perpendicular distance as above.

Having thus endeavoured to show, that when coal-fields are not viewed upon a limited, but an extended scale, that they form either circular, or more generally, long elliptical basons, or portions of this figure, though sometimes in an inverted position, it must from this circumstance appear evident, that every coal and its accompanying strata will crop out and meet the alluvial cover, excepting when they are cut off and prevented from doing so by slips, or where they form portions of an inverted bason, or take a counter dip, as may be seen by inspecting the preceding figures relative to the shape of coal-fields. In the foregoing examples, the coals and accompanying strata are considered as keeping nearly the same distance from one another in each coal-field, and that they keep nearly the same parallelism as to the angle of dip and rise, with the quality of the coal unaltered in the several coal-fields produced by the slips and dislocations of the strata. In many instances we find this to be the case; but many changes are found to be produced, such as alterations in the angle of dip and rise of the strata before coming to slips or dislocations, a general change in the angle of dip and rise in the coal-field formed beyond them, some of the coals varying in thickness in the different coal-fields separated by these slips, and sometimes the thickness of the strata betwixt two beds of coal is doubled; at other times the distance betwixt them is rendered so little in some instances, as to be no longer visible; by which means, two seams of coal which were wrought as distinct beds of coal, are joined together, form one bed of coal, and wrought as such. Instances are also found of beds of coal composing a coal-field on one side of a slip disappearing on the other side; but this does not take place with the chief or main beds of coal. Differences, in point of quality, are occasionally found in the coals divided by slips and dislocations, though it is clearly evident that it is the same formation of coal-field on each side.

Although coal-fields are of the form as before described, it must be remembered that the extent of a single coal-field, in the line of bearing, is found to be several miles in length, suppose six miles; that is, they are sometimes found of this extent, without any great dislocations, as to have the effect of forming new coal-fields; and they are found in the line of dip and rise to extend above two miles. Other coal-fields are very small, not extending to half a mile in the line of bearing; yet, from the extent of the coal-basons, we must remark, that, in considering the shape of a small portion of a coal field, and the operations connected with the working of it, the idea of the bason-shape is abandoned, and the coal field and beds of coal are considered as a regular lying inclined plane. This, upon a limited scale, is not far from the truth, considering the great extent of the basons; but this idea will evidently be found very erroneous the instant a coal-field is viewed upon an extended scale, and extensive operations pursued in it.

The next point to be described, is the methods commonly pursued by mineralogists and miners in searching for coals, premising, however, that a clear idea has been formed of the facts before stated, as to the general natural phenomena connected with coal-fields. In making a survey in search of coals, there are two distinct points of survey to be attended to.

1*st*, The searching for coal in a district of country where no coals are known to exist.

2*d*, The searching for coal in a district of country where the coal formation is known to be, or where coals are working at no great distance from it.

In searching for coals in a district of country where no coals are known to exist, the first point for consideration is the general aspect and outline of the country under survey. Although, from taking this general view, we cannot determine whether it contains coal fields or not, yet, if the country is composed of hills or mountains, with steep acclivities, precipitous rocks, and sharp and rugged summits, with narrow valleys betwixt the mountains, we have no reason to expect that strata will be found there containing coal; and excepting this very obvious and plain feature, as to aspect, we do not know any other upon which we can conclude with any degree of certainty, whether coals will be found in a district of country or not.

It must, however, be remarked, that, in the second coal formation of Werner, as noticed in the geological view of the situation of coal fields, that though the great beds or masses of greenstone overlying a coal-field do not rise into what may be denominated mountains, they form, in this singular variety of the coal-field, hills, several hundred feet above the level of the sea, with rugged precipices, rudely columnar, in some instances nearly 200 feet high, under which coal is not only found occasionally, but in amazing thickness, though not of great extent. This is therefore a rugged aspect, formed by a peculiar kind of rock, under which coal is occasionally found.

This, we apprehend, is all that can be said regarding the general aspect of a country, as to whether it contains the coal formation or not; for when it is known that coals are found not only at great depths under the sea, but at very considerable heights above it, even so high as to form with their concomitant strata considerable hills, we may, from these circumstances, infer, that coals are found under every variation of surface, such as the ocean's sandy shores, the recent and old alluvial covers, and also under every kind of varied hill and dale. But we must observe, that there are also vast districts of country with all these varieties of surface, and exactly similar in aspect, under which no coals are to be found. This shews how limited our conclusions are from the aspect of a country, whether it contains the coal formation or not.

It thus appears that no conclusions can be drawn, with any degree of certainty, from the aspect of the country, as to whether coals are to be found in it or not. But mineralogists, who have surveyed many countries, and who have had an opportunity of examining the peculiar character, outline, and forms of mountains and hills, arising from the nature or kind of rocks constituting their mass, conclude, from the aspect in general, very correctly, of what rocks they are formed; but this discrimination is not applicable to coal-fields, as the rocks which compose the various beds, alternating with the coal, are, in general, much softer than the mountain rocks, and form few or no precipices. Where the coal formation forms a group of hills, they have the appearance of some of the transition class, with the exception of being softer in their contour and outlines; but this does not afford a distinction of character sufficiently precise, as the long running ridges of hills of moderate elevation, forming the hill and dale country which contains coals, present, like other ridges, a line of horizon nearly level, with few or no indentations, and no abrupt precipices, excepting when greenstone or basalt occurs, either overlying the strata, or forming a dike in the coal-field, and rising above the other softer strata. This situation of the greenstone is altogether different from that of the greenstone in the second coal formation of Werner. The long ridges containing coal, and forming what is termed a tame horizon, are very similar to the hills composed of chalk. It is to be remarked, that the line of bearing of the hills and dales is somewhat in the direction of the large rivers, or main trunks of rivers, which drain the district of water.

Since so very little can be depended upon, as to the conclusions to be drawn from the aspect of a country regarding coals being found in it, the next step is to examine the surface, or alluvial cover, which, in most cases, hides the strata underneath from view. Were it not for this cover, the searching for coals and other minerals would be a very plain and simple process; and, as this cover is frequently many fathoms in thickness, and sometimes of very heterogeneous composition, the pitting or boring through it is often attended with considerable difficulty.

If the district under survey for coal is composed of the bleak and sandy shores upon the margin of the ocean, or of the recent alluvial land at the mouth, and along the course of large rivers, whose waters move with a slow current, it very seldom happens that any symptoms of the kind of strata underneath can be discovered, even although these covers be examined to a considerable depth, as it is not common to find any fragments of the adjoining rocks mixed with them. We have seen these covers passed through to the depth of ninety feet without finding even the smallest fragments of stone, nothing being found larger than grains of sand. As these sandy and earthy deposites, which cover the rocks upon the margin of the ocean, and by the sides of slow running rivers, are very flat, and rise inland with an imperceptible angle of elevation, it seldom happens that any discovery of the rocks can be made, either in the beds or sides of the rivers and brooks which flow through them; therefore, in all such cases, recourse must be had to pitting and boring, in order to ascertain the kind of rocks underneath, and whether they belong to the coal formation or not. The plans commonly adopted for passing through the alluvial covers will be afterwards described, when treating of boring.

As we proceed inland, the recent alluvial cover becomes thinner, and disappears at its line of junction with the old alluvial cover, which line is, in most cases, very distinct. This kind of cover forms frequently a hill and dale country, considerably elevated above the level of the sea. The rivers and brooks which intersect it often expose the rocks to view, so that it can be determined, from inspection, to what class they belong. Therefore, in such a country, the first step to be taken in the survey in search of coal, is to investigate the beds and sides of every river and brook, noting the kinds of rock which appear, and also their dip and line of bearing. Every piece of broken ground and quarry must be examined in the same manner.

Springs of water require also to be examined; and although those which have an ochery deposit, are not to be supposed as affording unequivocal symptoms of coal, yet they are sometimes indicative of coal, or of ironstone accompanying coal. At the same time, it must be remarked, that these ochery deposites are found in waters which drain through common clay; and often very abundant from peat earth.

If, after heavy rains, which cause springs to flow copiously, small bits and grains of coal are found thrown out by the water, we have reason to conclude that coal is to be found at no great distance; and the searching for it must be proceeded in accordingly.

If, in the sides of rivers, brooks, or broken ground, a black sooty appearance is seen, this is frequently found to be the crop or outburst of a coal, and ought to be followed in the line of dip, by throwing an open trench. If it is the crop of a coal, the sooty appearance will become more compact as the operation proceeds to the dip. Small shining angular pieces of coal will be found mixed with it; and at last coal, apparently solid, but still very friable, will succeed, resting upon the pavement of the coal. The trial must proceed until the roof is found firm, regular, and parallel with the pavement. It frequentlly happens that all the natural cracks and fissures of the coal near the crop are filled with clay, which gives the coal a very unpromising appearance; yet this disappears after proceeding a few fathoms more to the dip. When a coal is found regular as a stratum betwixt the pavement and roof, we conclude that the full thickness of that particular bed of coal is found, providing we see no appearance of any of the dislocations or troubles before described, which must be kept in view when drawing conclusions from the appearance of coals, when thus found. After a bed of coal is found regularly formed, as before described, if its absolute situation and thickness farther a dipping is required to be known; or, if the strata lying either above or below it are to be investigated in search of other beds of coal, these points must be ascertained by pitting and boring.

In the face of steep banks of earth, even when the ground is not broken, the crops of coals are frequently observed by a black colour given to the soil; which appearance is also observed in lands which have been recently ploughed. When this appearance is seen in the face of a steep bank, the search for a bed of coal should proceed to the rise, or a little higher up the bank than where the black colour appears. But when this appearance is found in flat ground, a trench must be cut at right angles across it, so as to ascertain the line of dip; and, when this is found, the investigation will go forward in the line of dip, as before directed.

If, by the sides of rivers or brooks, pieces of coal are found much rounded in the angles, it is to be inferred that the bed of coal from which the fragments have been detached is at a considerable distance from the spot where they are found; but if the angles are sharp, it may be concluded that the bed of coal from which they come is at no great distance.

In digging through the old alluvial cover which rests upon a coal-field, numerous fragments of coal, and of all the accompanying coal strata are found, as well as small rounded gravel of the mountain rocks, and large boulder stones. It is remarkable that the fragments of coal, and of the coal strata, are, in general, not worn by attrition, but are sharp and angular; which show, that the formation of this old alluvial cover was by water, in a very different state from that by which the recent alluvial cover has been formed, and is daily forming. Yet though these appearances give evidence that the district contains the coal formation, they do not point out in what direction the crops of the coals from which they have been detached are to be found. It is proper to remark, in this place, that though unequivocal symptoms of coal are found, and that it may be inferred that we are within a coal formation district, yet we can conclude nothing satisfactory, as to the thickness of the beds of coal, until proper trials are made.

Lime stone, which abounds with organic remains, particularly if it is of some considerable thickness, is, in many cases, an index to a coal-field; as it is much harder than the common strata of a coal-field, it crops frequently out to day, that is, it is distinctly seen at the surface. We find also, that these thick beds of limestone are commonly found in the lower series of the strata of the coal formation, for which reason, whereever a bed of this kind of limestone is found, the dip should be first ascertained, and then the coals searched for in the line of dip; for although coals, and their accompanying strata, exist to a great depth under these beds of limestones, it seldom happens that any coals of good quality, or workable thickness, are found there.

If a district of country is to be surveyed, in which are mountains, or elevated ground abounding with rocks, these require in the first place to be surveyed. In most instances there is no great difficulty in determining to what class of rocks the mountain formation belongs, as some part of them is laid open by the streams of water with which they generally abound. If it is found they are composed of primitive or secondary rocks, as before enumerated, it is certain that no coals will be found under them; therefore the next point to be ascertained is, the dip of these rocks, because, in searching for a coal-field, it will be necessary to follow the primitive rocks in the line of dip, as the others follow in overlying succession. If the coal formation exists in that district, it will be found by tracing forward in that direction, and if found at the foot of primitive or secondary mountains, the strata of the coal-field will be found lying in a conforming situation with the face of the mountains, and forming a very great angle with the horizon. If the coal formation exists at the foot of such mountains, it will be in most cases easily discovered in the ravines and hollows formed by the mountain streams; and in many instances the coal and accompanying strata are seen so clear and distinct, that the operation of mining and working the coal may be immediately commenced without farther investigation; but as the edge coals are more difficult and expensive to work than the flat coals, it may be desirable to trace the coal-field farther onward. It has been found from experience, that when edge coals are thus found resting upon primitive or secondary rocks, that they form part of a great bason, and that after dipping to a considerable depth, they begin to deflect from their verticular line and form a hollow, or, what is termed by miners, a trough or bason, upon the opposite side of which the edge coals are found forming flat coals, rising in an opposite direction, as represented in Plate CCCLXXXIX Fig. 7, where I is the transition rocks, and *a*, *b*, the coals in the coal-field, A forming a trough or bason.

There are also instances of coal-fields where the edge coals have been wrought to a considerable depth without any symptom of their deflecting, and adjoining them flat coals are found cropping or rising towards the edge coals, as represented Fig 9. We are inclined to think that, in this instance, the edge coals, *a*, *b*, *c*, pass under the flat coals, *d*, *e*, *f*, at a great depth, and deflecting from the vertical line form the flat coals of the bason, *a*, *b*, *c*, on the opposite side; and that the great bason, formed by the edge coals thus deflecting, is filled up by a distinct set of flat coals and their accompanying strata, *d*, *e*, *f*. We are of opinion that the very interesting coal-field, south from Edinburgh, is of this kind of formation. All these varieties, now and formerly described, require to be kept in view, together with the various dislocations and troubles incident to coals. In prosecuting the search for coals beyond the edge coals, it generally happens that a short distance from the mountain foot or rising ground, the alluvial cover prevents the rocks or strata being any more seen; in this case, the whole district under survey must be minutely investigated, in particular all broken ground, beds of rivers, quarries, and new formed ditches, where it is probable, if the alluvial cover is not very thick, some vestiges of the strata will be seen, but if no vestiges of the strata can be discovered, the next step is to proceed with pitting and boring.

The foregoing rules are such as are at present adopted in surveying a district of country in which no coal is known to exist.

The next case is the searching for coal in a district of country where the coal formation is known to exist, or where coals are working at no great distance from it.

If it is only known that the coal formation exists in the district, without any particular account of the beds of coal, the dip, line of bearing, or form of the coal-field; the survey and investigations must be proceeded in according to the rules laid down, connected with the particular circumstances of the surface of the country under survey; and if coal cannot be discovered by minute investigation, the search must proceed by means of pitting and boring.

If coals have been wrought, or are working in the district of country under survey, particular inquiry must, in the first place, be made, as to the quality and thickness of the coals, their general dip, line of bearing, and shape of the coal-field, also if any dikes or slips are known to exist, and if they do, to learn their line of bearing, and extent of the dislocations of the strata produced. The form of the coal-field is important, as, without a knowledge of this, much difficulty and great mistakes may be the consequence. When numerous collieries are opened in a district of country, the subterranean geography of the strata is well known, the series or system of beds of coal composing the coal-field are ascertained, with their accompanying strata; and to an experienced miner they are as well known as the leaves of a book, excepting in cases where great derangement and dislocation of the strata have taken place. It is also of importance to know if the coals are liable to such troubles as alter their quality, render them thinner, or if they are separated occasionally by bands of stone, which in some instances separate the upper and lower parts of the bed of coal to such an extent as to form two coals.

The same general survey and investigation of the district must be followed according to the rules formerly laid down; and if no distinct view of the coals or strata can be seen, so as to draw accurate conclusions, the farther investigation must proceed by boring, care being taken not to overstep the coal-field, or beds of coals which are known to exist. This mistake will take place with the most cautious, if the form of the coal-field is not known and attended to.

The art of boring for coal is one of the chief points in mining, in order to ascertain the strata and beds of coal, before any great operation is commenced in winning or establishing a colliery, in which a great capital is frequently invested.

The rods commonly used are made of the best Swedish iron, about an inch and a quarter square; each rod is three feet in length, having a male screw at the one end, and a female screw at the other; these are what are named the common rods. The chissels for boring are eighteen inches in length, and are from two inches and a half to three inches and a quarter in breadth at the cutting edge, faced with the best steel; with these one short rod is connected, called the double box-rod, to which the chissel is screwed. It is also eighteen inches long, so that the chissel and box-rod together, form a three feet length equal to the common rods. There are also three short rods, named cut rods, of a foot, eighteen inches, and two feet in length, which are attached to the brace head, to render the height above the mouth of the bore suitable for the men to work the rods with effect; by this arrangement, the whole set of rods divides easily and accurately into yards and fathoms, for the more correctly keeping a journal of the strata passed through. What is termed the brace-head rod is eighteen inches long, having two large eyes at the top, set at right angles to each other, through which arms of wood are put, by which the men lift and turn the rods in boring. There are besides a number of other instruments connected with the boring rods, viz.

Wimbles, of various kinds.
Sludgers.
Rounders.

These are occasionally attached to the rods, as after described. There are also keys of different kinds for supporting the rods, and unscrewing them, when drawing them up, or letting them down into the bore hole; and when triangles are used so as only to unscrew four or five fathoms of rods at a time, topits, or top-pieces are used for each length of rods so cut, and an instrument, named the runner, is used for taking hold of the topits. Besides these, there are several instruments named beches, with contrivances for catching hold of the rods when they break down in the bore, which is not an unfrequent occurrence. When bores are only to be a few fathoms in depth, the whole operation is performed by manual strength; but when a deep bore of any consequence is to be made, a set of lofty triangles of wood is placed over the bore-hole, with a pulley at top, through which a rope is passed; one end is connected with a crane or windlass at the surface, to the other end, an oval iron ring, named a runner, is attached; by these means the rods are drawn up and lowered down with great facility.

In England, particularly in the Newcastle district, there are professional master-borers, who undertake to put down bores for coal, and give a precise journal of the strata passed through. The average price of boring in England and Scotland, where no uncommon difficulties occur, is six shillings for the first five fathoms, and an increase of six shillings each fathom for every additional five fathoms, viz.

1st 5 fathoms	6s.	£1	10	0
2d 5 do.	12s.	3	0	0
3d 5 do.	18s.	4	10	0
4th 5 do.	24s.	6	0	0
20 Fathoms.		£15	0	0

In this manner the price increases regularly with the depth; and in all common cases the master-borer finds and upholds the boring rods, but there are instances where the price is considerably higher than the above rate.

In Scotland, boring for coal is scarcely known as a profession, but there are master sinkers who occasionally bore, and who perform the operation with accuracy.

The boring tools are represented in Plate CCCXC. Fig. 1. in progressive numbers, viz.

No. 1. The brace head.
2. Common rod.
3. Double box-rod.
4. Common chissel.
5. Indented chissel.
6. Do.
7. Cross-mouthed chissel.
8. Wimble.
9. Sludger.
10. Rounder.
11. Key for supporting the rods at the mouth of the bore.
12. Key for screwing together and unscrewing the rods.
13. Topit.
14. Bechè.
15. Runner.
16. Tongued chissel.
17. Right-handed worm-screw.
18. Left handed do.
19. Finger grip.

The mode of conducting a series of bores in exploring the strata for coal, is next to be explained.

Plate CCCXC. Fig. 2. represents a district of country, in which, after a regular survey, coal strata, and the appearances of coal, have been found, having an evident dip to the south, as represented in the Figure. In this case, a convenient spot should be chosen upon the north part of the district to be explored, in order that the different bores may be carried southwards in the line of dip; the first bore is therefore put down at No. 1. suppose to the depth of sixty yards In this depth it is probable many varieties and alternations of the strata will be passed through, as exemplified in the sections of the strata; but for the sake of perspicuity, only a few strata are shewn in the figure, which strata are distinctly inserted in a journal as to their quality and thickness, and specimens of each carefully kept. The bore No. 1. passes through the strata *d*, *c*, *b*, *a*, without finding any coal. And as in proving a district with a regular series of bores, it is more economical to do so by means of bores of a moderate depth, than with very deep ones, which are attended with great expence, provided there be no particular difficulty in passing through the alluvial cover, which might render a number of bores very expensive. Suppose that, in the first instance, bores of sixty yards deep are resolved upon, as at No. 1 before mentioned, and that the dip of the strata is 1 in 10, the consideration then is, at what distance from No. 1. bore southward, will a second bore at the same depth strike the first stratum *d*, found at No. 1.? The rule is, multiply the depth of the bore by the dip, viz. 60 by 10 gives 600 yards, which is the distance required. In this manner the bores No. 2, 3, 4, and 5, are successively placed, with this particular exception, however, that the point of surface where the first bore is put down must be considered as the point of level to which the top of all the other bores relate. If therefore the top of No. 2. bore is 10 yards higher than the top of No. 1, that additional depth must be added to the bore ere it can be expected to reach the stratum *d*. On the other hand, if the top of any succeeding bore is under the level of the top of No. 1, bore, suppose 20 yards, that bore will reach the upper stratum of the former bore at a depth less, by 20 yards, than the depth calculated from a horizontal line from the top of No. 1. bore. Ravines frequently cut the strata in various directions, as at A, so as to lay the strata open to view; and if these are very deep, an advantage may be gained by boring there, and proving the strata to a considerable extent by a bore of moderate depth. In all instances where a series of bores are carried on, a correct and distinct profile of the surface ought to be made in the line of the bores. In No. 2. a coal is found near the surface, and another at the bottom of the bore, which last rests upon the first stratum *d*, found in the bore No. 1. The bore No. 2. is continued a few feet farther, until it is decidedly ascertained that it is has reached the stratum *d*. These two bores have thus proved the strata to the depth of 120 yards. No. 3. bore having been placed according to the rule before given, it passes through two coals near the surface, and after being put down nearly to its proposed depth, it strikes the stratum *h*, which is the upper stratum found in No. 2. bore; but as a coal was found in No. 2. under the stratum *h*, the proof is rendered more complete by continuing the bore through that coal. This bore, with the two former, proves the strata to the depth of 180 yards. No. 4. bore having been placed in the same manner as the former, a coal is found after passing through a few yards of the strata, and the bore is continued downwards until the two coals found near the surface in No. 3. have been passed through. This, with the three former bores, ascertains the strata under examination to the depth of 240 yards, so that to reach the lower stratum *a* of No. 1. the bore No. 4 would require to be put down to the said depth of 240 yards. The bore No. 5. being placed in the same manner as the former, a coal is found within a few yards of the surface; but, after reaching the depth at which the coal at the top of No. 4 bore should have been found, strata altogether different occur. In this case it is usual to go on with the bore ten or twenty yards farther than the intended depth of the bore, to ascertain the alternations of the strata. In some cases no coals of any value will be found, as in the present example, the cause of which is, that a slip or dislocation B of the strata has occurred, throwing up all the coals passed through in the former bores, and that of such a magnitude that the strata *b*, *a*, of the bore No. 1. are found immediately after perforating the slip; and within a few yards of the surface, in place of being found at the depth of 300 yards, as would have been the case had the strata continued at the regular dip of 1 in 10, and no dislocation had taken place. Since dikes, slips, hitches, and troubles of every kind and degree, as formerly mentioned, occur in coal-fields, examples of which are given in the preceding part of this treatise, it will easily be seen, by an inspection of these figures, what difficulties may occur in boring a coal-field which is much dislocated and troubled. Some coal-fields are so intersected with these as to bewilder the ideas even of the oldest and most experienced miners; for instance, since slips are of every magnitude, as regarding the extent or distance the particular strata are separated in a vertical direction, it not unfrequently happens that a lower coal is thrown upon one side of a slip, directly opposite to an upper coal situated upon the other side of it; so that if the two coals are of the same thickness, erroneous conclusions are most inadvertently formed, and mistakes with the most cautious will take place. Very many instances might be given of these anomalies found in the practice of mining, but it would be endless to elucidate them by figures. In the example given of a progressive set of bores, it is evident that the first coal likely to be found to the southward of No. 5. bore, and in the new coal-field formed by the upthrow slip, will be that found in the bottom of No. 2. bore; and if so, there is reason to conclude that all the other superincumbent coals will be found in succession southward, excepting some great dislocation or off cut of the strata takes place to interrupt their regularity. Caution must also be observed, in approaching primitive or secondary rocks, it being found, as before mentioned, that coals and their accompanying strata flatten in the line of dip towards these rocks, form a trough or bason, from which they rise suddenly, and form edge or half edge strata upon the face of those rocks.

If a line of bores is to be conducted from the dip of the strata towards the rise or direction of the crop, the same rules hold as to the placing the bores at the proper distances from each other, according to the dip or the angle of inclination made by the strata with the horizon; with this correction, that the bores are placed some yards nearer each other than the distance resulting by multiplying the dip by the depth of the bore, in order not to overstep the last strata passed through in the preceding bore; for if any of the strata are overstepped, several of them will not appear in the journal, and a valuable coal may be in these strata which have escaped being bored through. The general rule in this case is to place each successive bore so that the first of the strata passed through shall be the last which were passed in the bore immediately preceding. The bores No. 4, 3, and 2, elucidate this principle in boring from the dip to the crop; but suppose that the bore No. 2. had only gone to the depth of the stratum *f*, and that the bore No. 1. was put down in the position as marked in the Figure, in this case the stratum *e*, with the coal immediately below it, would be overstepped, none of the bores would pass through them; of course they would not appear in the journal, and the existence of that coal would be unknown.

Having described the mode presently practised in boring in the crop and dip-line of direction, where the dip is known before the boring is commenced, the next operation to be described is the proof bores in the line of bearing, which are necessary in proving a coal-field in a district where coals were not known to exist before. The line of bearing being at right angles to the line of dip and crop, let it be supposed that these bores are to be put down at right angles to the bore No. 4. at the distance of four to six hundred yards; the one on the west, the other on the east side. (Plate CCCXC. Fig. 2.) After making the requisite allowance for the difference of level betwixt the top of these bores and No. 4. bore, the two coals found in the bottom of No. 4. ought to be found at the same depth in each of the bores put down in the line of bearing if the strata are lying regular and free from dislocations; having, however this correction in view, that as all coal fields are bason-shaped, and of very various magnitudes, the absolute line of level along any bed of strata deflects either inwards or outwards from the line of bearing, which is at right angles to the line of dip and crop; and, therefore, referring to the shape of coal-fields formerly discussed, it will be seen that bores put down in a proper bason-formed field, in the line of bearing, will strike the coals sought after sooner than calculated upon; and, in the case of the form being an inverted bason, the coals will will be deeper than calculated; in large basons this difference in the line of bearing will not be much when at a moderate distance from the dip-bore, but in a small bason the difference will be found considerable, for this very evident cause, that if the bason is not broken by dislocations of the strata, all the coals crop or come to day in the line of bearing. Having these corrections in view, if the coals are found at a depth corresponding to the calculations made from practical data, it may be concluded that the coals are lying in that field, so far as proved, fair and regular; but if these bores require to be put down to a much greater depth than was calculated upon before striking the coals found in the bottom of No. 4.; or if these coals are found much sooner than was expected, it may be then concluded that a slip or dislocation of the strata exists betwixt the two bores, throwing down the strata in the first instance, or throwing them up in the second. Under such circumstances a few additional bores will be required, to ascertain the coal-field still farther, and the line or direction of the slip, particularly if the dislocation is of considerable magnitude. The position of such bores can only be determined on by weighing every circumstance which may occur while the operation of boring is carrying forward.

If in proceeding with a series of bores where the line of dip is not known, nor consequently the line of bearing, it is an important and primary point to ascertain this, not only as regarding the situation of the coal-field, but how it ranges within an estate or particular property. The mode practised is by putting down three bores in the following position. Suppose a bore No. 1. (Fig. 3. Plate CCCXC) put down, which reaches a coal at the depth of 50 yards, at the distance of 300 yards a place is marked for No. 2. bore at B, and a place for No. 3. bore at C, equidistant from No. 1. and No. 2., so that the bores are placed at the angles of an equilateral triangle; then suppose the bores No. 2. and 3. to be put down, and that the coal is found in No. 2. at the depth of 30 yards, and in No. 3. at the depth of 44 yards; from this it is evident that neither of the lines AB, BC, or CA, are in the line of level, which in short distances, as before mentioned, approximates to the line of bearing, particularly in coals which have a very moderate dip. As No. 1. is the deepest of the three bores, and No. 3. the next in depth, this shews that the line AC is nearer the line of level, than either the lines AB or BC. The question therefore is, at what distance upon the protracted line BC, is the point at which, if a bore were put down, it would reach the coal at the same depth as at No. 1. viz. at 50 yards. It is thus resolved: as 14 yards the difference of depth betwixt the bores No. 2. and No. 3. is to 300 yards the distance betwixt them, so is 20 the difference of depth betwixt No. 1. and No. 2. to the proportion resulting, which is 428 yards, 1 foot, 8 inches; this distance, measured from No. 2. reaches to the point D on the protracted line BC, at which point D, the coal will be found at 50 yards deep, as at A; hence the line AD is the true level line of the coal or strata. A line drawn at right angles to AD, such as BF, is the true dip line of the coal. In this example, the dip, in the miner's language, is 1 in 14½, that is, in each distance of 14½ yards, measured along the line from B to F, the coal is found one yard deeper. Hence a calculation is easily made at what depth the coal would be found at any point of distance from B, along the protracted line BG, viz. by dividing the given length by the dip. If the distance from B to G in the line of dip is 455 yards, this, divided by 14½ the dip, gives 30 yards, which, added to 30 yards, the depth of No. 1. gives 60 yards for the depth at which the coal would be found at G. As any line drawn at right angles to the line of level AD, is the line of dip, so any line drawn parallel to AD is a level line. Hence, if from No. 3. bore, a line CE is drawn parallel to AD, the coal at the point E will be found upon a level with the coal at C, viz. at 44 yards. The point E may, however, be found on a level with No. 3. by a rule of proportion similar to the former, viz. as 20 yards the difference of depth betwixt No. 1. and No. 2. so is 300 yards the distance betwixt them, to 14 yards the difference of depth betwixt No. 2. and No. 3. the proportion resulting is 210 yards; which distance, measured from B, is found to be at E. Had this proportion been first tried, then A D drawn parallel to EC would have given the point D, upon the protracted line BC, where the coal would be found on a level with the coal at the point A. In this example, the surface is supposed to be level; but as this is seldom the case, the relative situation of the bores at the surface with each other must be accurately ascertained. If No. 1 is situated higher than either No. 2. or No. 3. the difference of altitude must be added to each bore, so as they may be equal to No. 1. which correction brings them to the same horizontal plane, and then the projection and calculations are made as before exemplified. It is by this theorem for finding the line and dip of level, that the most eligible spot in a coal-field or coal property can be selected; where, by sinking a pit, the coal, under all circumstances, can be wrought to the greatest advantage, particularly as to the drainage of the coal-field.

The process of boring, as before described, is the same which has been long practised, and which is in common use at present. A new mode was invented and brought forward under letters patent, some years ago, by Mr. James Ryan, from Ireland. The principle is very ingenious, and it is this. The common boring rods are the same as before described; but, in place of chissels, a forked cutting-tool is used, in the same way as formerly described in the process of boring; but, in place of the strata passed through being comminuted or ground to powder, a core or cylinder of the strata is formed; and as soon as the boring bit has advanced as deep as the shoulder of the fork, the rods are drawn up, and a pair of nippers substituted; these seize the core, break it off, and bring it up. In this manner the boring proceeds through the strata to the required depth, and each piece of core brought up, is laid in a horizontal direction, each piece regularly joining the preceding one at the line of fracture; by this means, a true section of the strata bored through, with the coals found, is as distinctly seen as if a pit had been sunk through them. Besides which, the dip or declivity of the strata is also ascertained. It is said that the true line of dip can also be found during the process of putting down a single bore, but it is apprehended that the accuracy of the result cannot be depended on.

Mr. Ryan made every proper exertion to bring his ingenious mode of boring into practice; a mode, the result of which was so satisfacfory, leaving no ambiguity as to the strata passed through, and particularly as to the thickness and quality of coals, in ascertaining which so great mistakes have unfortunately taken place, because by the new plan the strata and coals in their natural compact state are laid upon the surface of the ground. But highly satisfactory as this is, the plan has not succeeded, and is not yet known in common practice. Several eminent coal proprietors patronized Mr. Ryan, and gave his process a fair trial; the bores were not deep, but, so far as executed, they were satisfactory. The impression which the public has at present regarding this mode of boring is, that it is very expensive, and not practicable in deep bores. It is, however, but too well known, how much mankind are attached to old plans, strongly prejudiced against new ones, and that it is no easy matter to change particular habits; this may have operated against Mr. Ryan's invention, and have prevented success attending it. The bore-holes formed by the boring-bits are larger than those in common use, in order that the core may be about 3 or 4 inches diameter, and Mr. Ryan proposed by this plan to bore holes of more than one foot in diameter, to ventilate coal-mines, but it is supposed this did not succeed, or that the expense rendered it no saving. It is understood, however, that by this process, with boring-bits and wimbles of large size, alluvial cover mixed with gravel and boulder stones has been passed through, where the old plans did not succeed; and this kind of cover is the most difficult to bore through of any.

As boring for coal is always carried on in a line perpendicular to the plane of the horizon, and as coals and their accompanying strata, lie at every various angle of inclination to that plane, from nearly horizontal to the perpendicular line, it results that the thickness of the strata, or of any coal bored through, if lying at a great angle with the horizon, will measure considerably more than what they absolutely are, because the true thickness of any stratum or coal is only obtained by taking the measurement at right angles to the plane upon which each stratum or coal rests; for example, in boring through the flat-lying coal, Plate CCCXC. Fig. 4. the difference betwixt the line passing through it, perpendicular to the horizon, and that which is at right angles to the plane on which it rests, is so trifling as need not be noticed; but this difference betwixt the two perpendiculars, increases with the enlargement of the angle formed with the horizon so that in Fig. 5. the thickness of the coal, as ascertained by boring, is the distance *a*, *b*, whereas the absolute thickness of the coal is the distance *b*, *c*, that is, a line perpendicular to the plane on which the coal rests. In this example, the measurement of the coal by boring, is 16 feet, whereas its absolute thickness, *b*, *c*, is exactly six feet, producing an error of 10 feet. From these circumstances, it is not the practice to ascertain a coal-field composed of edge coals, by boring, because being nearly vertical, very few of the strata would be passed through, even with a deep bore; therefore, when edge coals are not laid open to view in a ravine where the alluvial cover is removed, it is the practice, if the cover is not thick, to cut a trench through it at right angles to the line of bearing of the strata, and as edge coals lie generally at a short distance from each other, a trench of two hundred yards in length will discover nearly that thickness of the strata; but if the cover is too thick for cutting a trench to the rock head, the plan is, to sink a pit a few fathoms into the rock, from the bottom of which two mines are carried in a level direction, at right angles to the line of bearing, the one to the rise, the other to the dip of the strata. By this plan, the thickness and quality of the coals will be accurately ascertained. Fig. 6. shews the plan of proceeding with edge coals, *a*, *a*, are the edge coals, *b* the pit, *c*, *c*, the mines which intersect the strata.

With regard to searching for coal in what is termed by Werner the second coal formation, composed of the newest flœtz trap rocks, it is attended with more difficulties than are found in any other of the coal-fields. In this formation the coals are found of uncommon thickness, in some instances 100 feet, the prevailing strata above the coals, are various alternating beds of soft slate clay having very little tenacity, with sometimes a few beds of sandstone; and over these, next the surface, thick beds of greenstone; which, where dislocations of the strata have taken place, form high precipitous cliffs, such as greenstone precipices always assume. The coals found in these fields do not extend over a great district of country; in some instances they do not extend to a mile in length, the coals lie irregularly, and in a short distance vary from lying moderately flat to very steep.

Coal-fields of this singular kind have been found more by accident than from regular surveys and minute searching, for this reason, that the masses of greenstone present such an unfavourable appearance, and so forbidding, that trials by boring would scarcely be recommended by a mineral surveyor, particularly as limestone is more frequently found under very thick beds of greenstone than coal, with this difference, however, that the strata accompanying limestone in such cases, are stronger and more compact. If, in such instances, no vestiges of coal can be found, where the alluvial cover can be cut through near the crop of the coal, the next step is to bore beyond the edge of the greenstone, and also to search for the softer strata lying under any of the greenstone cliffs, which when found, a bore may be put down to any requisite depth to ascertain the strata; and if coals are found there, it is probable they will be found under the greenstone in the flat part of the country, which also must be ascertained by boring. If coal is found in one place, its dip, line of bearing, and extent, require to be found according to the process before described. These uncommon beds of coal are of various quality, some parts of them being hard, others soft, of a rich caking quality; but by far the greatest part is of an inferior kind, having sulphur combined with it, and yields, when burnt, ashes of a dark reddish brown colour, which is one of the peculiar characters of all sulphurous coals. Such coals are very liable to spontaneous ignition, after being opened up and wrought for some time.

Glance coal, which is the blind coal of Scotland, and the stone coal of Wales, is sometimes found alternating with the other kinds of coal; at other times, the common coals pass into this kind; it is, however, more commonly found in Scotland, where greenstone abounds in the strata, and is very abundant in Ireland.

No rules can be laid down for searching a district for this coal, beds of it have generally been found by accident.

For particular information regarding the different kinds of coal. (See the Article Coal.)

Bovey coal, being wood, or great collections of trees found in the alluvial cover, semi-mineralized, and lying nearly horizontal, it cannot, in strict mineralogical language, be named coal, though some of it is so like coal, as to be termed brown coal. The only considerable extent of this kind of coal which has been found, and continues to be wrought in Great Britain as fuel, is near Exeter in Devonshire. As its existence in any district of country cannot be traced by analogy, as coals can be, from a regular series of rocks, no rules can be given as to searching for it; and it is apprehended that this kind of ligneous deposit is but sparingly scattered over the globe. It is found in Europe, in the districts of Germany, Denmark, Prussia, Italy, Greenland, and the Faroe Islands; and probably exists in other quarters of the globe. The drift-wood which has greatly accumulated, and continues to accumulate, along the sides of some of the great rivers of America, will, it is very probable, at no very distant period, be covered with alluvial soil, and be converted into bovey coal. From this view of its geographical position, it is more likely to be found in the recent than in the old alluvial cover; and more probably not very distant from the line of junction betwixt them, where the rising grounds point out to the eye great districts of country, which very evidently were occupied by water previous to the extensive districts of rich alluvial lands being formed by deposits from the rivers.

In surveying a district for coal, both lime and ironstones may be discovered. In some instances, limestone forms the roof of coal, but in the extensive coal districts, the thick and valuable beds of limestone are found in the lower series of the strata, under all the main beds of coal. Limestone being very hard, and not easily decomposed, frequently crops or bassets out to day, hence more lime rocks have been discovered by surveying the surface than by any expensive process of boring.

In searching for ironstone, it is frequently found exposed to view in the broken ground; but if this is not the case, numerous small pits must be sunk along the district under survey, and a series of bores put down if necessary. Few fields of ironstone have been fitted to a great depth, and drained with machinery. The greater part of the ironstone mines in Great Britain are either wrought level free, or are drained and wrought in connection with coal mines in the same stratification.

Having thus described the position of coal in a geological point of view, particularly its relation to the other strata composing the upper part of the globe; and having also stated the kinds of alluvial cover which rest upon it, the dislocations incident to the strata, the changes in the beds of coal termed troubles, the mode of surveying a country for coal, the process of boring for it, and asertaining the different strata, the next department of mining to be described is, the manner pursued to render a coal workable; termed the fitting or winning of a coal.

If a coal, or a number of coals, are found to exist in a coal-field, the first obstacle which prevents a pit's being sunk to any considerable depth is water, which is generally found in great quantity, particularly in the first opening of a coal-field, (if the pit is sunk near the crop.) which water, whether found in pits of very moderate or very great depths, proceeds from the surface of the earth, though a contrary opinion was once held; it being evident and certain, that the source of all water found in mines is rain, which percolates through the alluvial cover, excepting in those cases when coals are wrought under the waters of the ocean; for, it was shewn in the vertical section of the strata, that every stratum, however deep it may be from the surface in any one place of a coal-field, always rises till it meets the alluvial cover, comes to day, or crops out, as it is termed, excepting it is met by a slip or dislocation of the strata. If the crops of the strata are covered with alluvial matter containing water, such as gravel, quick sand, or any kind of soil pervious to water, this water will percolate through the pores, fissures, and beds of the strata, and force its way into that place of the pit or mine where the lateral resistance is taken away. If the strata crop out into beds of rivers, this circumstance produces, in general, an uncommon growth of water in the coal and adjoining strata.

From the circumstance of the water being so abundant in coal-fields, and presenting such an obstacle to the operations of the miner, coal-fields are divided into two kinds, viz.

1. Level free coal.
2. Coal not level free.

The level of the surface of the ocean being the lowest point for drainage upon the surface of the globe, all coals and strata situated at a higher level than this surface are physically level free; and all coals and strata situated under that line are physically not level free. Therefore, in a general point of view, the surface of the ocean is strictly the line which divides these portions of coal-fields which are level free, from those which are not level free.

Though this definition is true in a philosophical point of view, many coal-fields, though level free, are situated at such a distance from the shores of the ocean, or arms of the sea, that the expence of bringing up a level or mine would be so great as to render such an operation out of the question; and therefore, in the practice of mining, if a coal-field, or portion of it, is so situated above the surface of the ocean, that a level can be carried either from that point, or from any hollow ground inland, till it intersects the coal, such field of coal, situated above the point of intersection, is termed a level free coal; whereas if a coal-field, though situated above the level of the ocean, cannot, on account of the expence, be drained by a level or mine, but by machinery, such coal-field, or portion of a coal-field, so drained, is, in the miner's language, termed not level free, though it is physically so.

From these principles, it is obvious that all coals and minerals situated under the level of the ocean must of necessity be drained by machinery; and that all coals situated above that level may be either wrought level free, or by machinery, as may be thought most expedient. This expediency is a matter of calculation; viz. whether, in draining a given area of coal-field, the estimated expence of driving the level, and upholding the same in repair, is less than the estimated expence of erecting an engine with all its appendages, taking into calculation the annual expence of working and upholding the same; to which must also be added, a sum for contingencies. It must also be considered, that the level is constantly effectual in its operation, and is not affected by additional feeders of water; whereas each additional feeder of water to an engine always produces an additional expence; besides, the engine wears out, and must be renewed, or, if sold at any time, does not in general bring one-third of the first cost. In these calculations must be considered the time required for completing the winning in both ways; and if the time required for executing the level greatly exceeds that for erecting the engine, this circumstance alone may, in some cases, produce a determination to erect an engine in preference to making a level, though the latter was found in calculation to be absolutely less. There are instances, however, where, in order to save time, it may be expedient to make a partial winning, of little depth, either by a day-level, or by machinery; and while the coal laid dry by this winning is working, a deep day-level is progressively bringing forward, which, as soon as it intersects the coal, and communicates with the engine level, supersedes the use of the engine.

Besides these levels which drain coal-fields of water, and render them workable, there are other levels of more limited operation, used in mining. These are named off-take levels, or drifts. The object of these is, that when a coal is to be won by an engine, the mouth of the engine pit is so situated as to the ground adjoining, that, at a moderate expence, a level can by brought up to intersect the engine pit a number of yards under the surface, so that the water of the mine, in place of being delivered at the surface, is discharged into the off-take drift. The lower down this kind of level, or off-take drift can be procured with ease, the greater will be the advantage in lessening the column of water to be lifted in the pumps by the engine. From 20 to 30 fathoms off-take is a considerable object, as that depth saves what is termed a lift of pumps; even 10 fathoms off-take is of consequence to have. These levels are not only of use in lessening the load of water on the engine, but if coals are intersected by them, they will intercept all the crop water to the depth of the point of intersection, and prevent it from going down upon the dip part of the coal, where it would be a heavy load on an engine, if, after intersecting the engine pit, the level is carried forward till it intersect the coals, through which the pit is sunk, all the crop water of these upper coals will also be intercepted. Such levels are not only of use in the winning described, but if a new deep winning is made to the dip, the crop water is not only prevented from descending to the pit bottom, but the advantage of discharging the water raised by the engine into the level is also obtained.

The most prominent advantages being thus stated, regarding day-levels, we have now to state the manner in which they are executed.

As, before the discovery of the steam engine, the coal-fields which could be drained by hydraulic machinery were comparatively very limited in number, and as the draining of water by men or horses was not only very expensive, but very limited as to the depth at which water could be raised, the driving of day-levels was a primary object with the early miners; and we are astonished when we survey the works of this kind executed by them, both as to depth and extent, and that before the application of gunpowder to the blasting of rocks. Without this powerful auxiliary of the miner, it is not easy to comprehend the extreme labour and patient perseverance required to pass through the very hard rocks which were met with. This seems to be the cause of the levels executed in the early periods of mining being of so small a size that a man has just room to creep through them.

Many of the levels of the present day are only three feet in width, and four and a half in height. Although these dimensions are in general sufficient to carry off the water which may be found in the colliery, they are too small when the mine is to be repaired, or when sediment and obstructions gather in them. They ought not to be less than four feet wide, by five feet six inches or six feet high; this is abundantly large for carrying off water. But there are some day-levels, which not only are driven for carrying off the water, but as a passage at the same time for bringing out the coals from the mine. In this case, the width would require to be at least four feet six inches, or five feet, so as to admit of an iron rail-way to be laid in it; besides which, there require to be, at proper distances, wider places formed in the side of the mine, to allow the loaded and empty carriages to pass each other. These by-pass roads are regulated as to the distance from each other, according to the quantity of work to be performed. When a day-level thus serves a double purpose, the water is either conducted in a covered drain, cut deeper than the sole on which the rail-way is laid, or it is conducted along the side of the rail-way.

In other instances, a day-level is not only made to carry off the water from the colliery, but is constructed of such size as to form a canal, by which boats can be carried into the coal mine, and loaded for the market. These levels are of various dimensions, according to the extent of traffic calculated upon. The smaller kind is nine feet wide, by nine feet high, having from three to three feet and a half of water in depth. The larger dimensions in practice are nine feet wide, twelve feet high, with five feet depth of water.

In driving a common day-level, for the sole purpose of draining the coal, the point having been fixed for commencing it, if the ground is flat, part of it at first will be executed as an open cast or ditch, securely laid with flag stones in the bottom, and built in the sides with sufficient stone walls. The sole to be conducted in a line as nearly level as possible. If the alluvial cover continues, and becomes too deep for open cast, the mine or level must be arched, and the work conducted under cover. If the alluvial cover is soft, it will require to be secured in the sides and roof with timber, which can be drawn out, and used again, if the nature of the case admits of this being done; but if this is not the case, the timber must be so placed as to admit the side walls and arch to be built within it. In this way the level is carried forward until it has proceeded some yards under cover of the rocks, or strata of the coal-field, when, if the strata are strong, no more mason-work is required. The next point is the proper line of direction, so as to reach the coal to be drained in the shortest distance. This line is that of the true dip and rise of the strata; and that the mine is going correctly in this line is known when the divisions of the strata seen in the forehead of the mine, are parallel to the sole of it, which ought always to be level. If the strata form an angle with the sole of the mine, the direction is going oblique to the line of dip; and the greater this obliquity, the greater will be the protracted distance, before the coal can be intersected. In all cases where the strata are not soft and friable, the roof of the mine is cut in an arched form, which adds considerably to its strength; and wherever the strata are soft and friable, or where the level passes through slips and dislocations, the sides are built up and the roof arched with stone or bricks. The latter are generally preferred, on account of their occupying less room, are easily carried into the mine, and the work more expeditiously executed; it being a rule that the mine shall, in all such cases, be made of such a size as to admit the building, without narrowing the fixed dimensions of it carried through the rock. As a day-level proceeds forward, the air begins to fail, from the breath of the workmen, the use of gunpowder, and the issue of carbonic acid and hydrogen gas, which are sometimes found in great abundance; to remedy this, deal boxes or pipes, from eight inches to a foot square, are carried in from the mouth of the mine to the forehead, and lengthened as the mine proceeds. This generally produces a sufficient circulation of air, until it is found necessary to sink an air pit upon the level, by which a strong circulation of air is not only produced, but the mine stuff is more easily drawn up than taken out to the mouth of the mine. Formerly these air pits were sunk directly upon the level, but that mode is now given up; for this reason, that if any part of the sides of the pit gave away, the rubbish instantly choked up the level, and frequently occasioned much trouble and expence to get it cleared again. The practice now is, to sink these pits about eight or ten yards from the side of the level, and connect them by a side mine. In this manner, day-levels are carried forward for miles, and may be carried to any distance. If, in the progress of the level, workable coals are intersected before reaching the coal which is the main object of the mining adventure, an air pit may be sunk of such dimension as to be suitable for a coal-pit, by which coals may be drawn. Air pits generally do not exceed seven feet diameter; and they ought always to be of the form of a circle. Plate CCCXC. Fig. 7. represents a coal-field, where the fitting is made by a day-level; *a* is the mouth of the level at the surface of the sea, *b*, *c*, *d*, *e*, are coals intersected, and drained by the level. All the coals lower than the level can only be drained by machinery. A is a coal-pit sunk upon the coal *e*; if the level is carried forward, the coals *f*, *g*, and any other coals which lie in that direction, will also be drained, and may be wrought by means of the pit A. The effect of the level would be the same if the coals and strata had dipped in an opposite direction to that represented in the figure.

The chief difficulty or obstacle which has occurred in executing day-levels, is thick beds of quicksand which are found in the alluvial cover. Instances have been found in practice where ingenuity, determination, and resolute perseverance, could not command success; for although thick beds of quicksand can now be passed through in a perpendicular direction, by adopting approved of plans, the difficulty of passing through them in a horizontal line has not yet been surmounted. If such a sand-bed is found to obstruct the driving of a day-level; and if it is an object to carry forward the level from that particular point, the mode of proceeding is as follows. Fig. 8. represents the strata of a coal-field A, with the alluvial cover *a*, *b*, containing the bed of quicksand *b*. B is the lower part from which the level is required to be caaried in the direction B, *d*. But the quicksand renders this mode of operation impracticable. The pit BC is sunk through the quicksand by means of tubbing, as will be described when treating of pit-sinking; and when the pit has been sunk a few yards into the rock, the level mine or drift is carried forward to the point D, when the pit ED is put down, it having been previously ascertained, by boring through the alluvial cover, that the rock-head at F is a few yards higher than the mouth of the pit B. During this operation all the water and mine stuff are drawn at the pit B; but the instant the pit ED communicates with the mine, the water is allowed to fill the mine CD, and grow up both pits until it finds an issue at the mouth of the pit B. From the surface of the water at G, in the pit ED, a mine is begun of the common dimensions, and carried forward until the coal in search of is intersected. By this plan no level is lost. This kind of level is named a drowned level, a blind level, and also an inverted syphon. When a coal, or any number of coals, are intersected by a day-level, the operation of working the coal proceeds in the usual manner, as will be described when treating of the manner of working coal.

In carrying forward levels into a coal-field of such dimensions as to be used as a canal, the same general rules are observed as in driving a common-level, the only difference being in the dimensions; but, from the width being great, a greater proportion of the sides and roof requires to be built and arched for security, which greatly adds to the expence of the operation. When such under-ground canals or levels extend to a great distance, they can be easily ventilated without air-pits, on account of their width; or, if ventilation is necessary, it is accomplished either by air-pipes, or by wide bore-holes put down from the surface; so that if air-pits are found necessary, they are placed at a great distance from each other, and as the stuff produced in driving the mine is in great quantity, it is brought to the mouth of the mine by canal-boats; but rail-roads must be used at the forehead. This part of the operation is not commenced until the level has advanced about half-a-mile under cover. This mode of proceeding is represented Fig. 8. Plate CCCXCIV. where A is the canal which enters under cover at B, the stuff from which is taken out by means of rail-roads as far as the point C; at this place a step is left a few inches higher than the depth of the water, and the canal is filled. From the level of this step the mine is carried forward to the forehead D, and all the stuff produced is brought in carriages along a rail-road, and emptied into the boats at C. When this operation has advanced to a convenient distance, the rail-roads are lifted, and the step at C is formed with a platform C, *a*, having an inclined plane formed of the rock *a*, *b*, which reaches to the bottom of the mine. The sole is then carried forward in a true water level line in the direction *b*, *c*, until it is as far advanced as the forehead D. The stuff produced by this last part of the operation is carried along rail-roads; and the loaded carriages are drawn up the inclined plane *a*, *b*, by means of a jack-roll, or windlass, placed at *a*, where they are emptied into the boats at C. The next operation is to remove or cut out the step or bench of rock left at C. For which purpose, a temporary dam-head, made of deals, is placed across the canal at C, as high as the water, having clay at the back to prevent leakage; the step *a*, C, is then cut out as low as the bottom of the canal, and upon removing the temporary dam, the water fills the canal to the forehead D, to which point the boats navigate; and the same operation goes on successively to any required distance, viz. until all the coals or other minerals of the district, proposed to be laid dry, and wrought by the mine or level, are intersected.

When a coal-field is so situated as not to be rendered level free, the winning has to be made by means of machinery.

In the early periods of mining, the drawing of water from the mines was most laborious, when either men or horses had to be employed; and when this was the case, the mining operations were very limited, both as to depth and extent below ground. The chain and bucket engine was the most powerful of the machinery then employed, and when wrought with a water wheel, raised a great quantity of water; but the greatest depth to which it was applied, was from 40 to 50 fathoms. The machines or engines presently in use for the drainage of coal-mines are.

1*st*, The hydraulic engine, or water wheel, with cranks and vibrating beams.

2*d*, The common atmospheric steam-engine, invented by Newcomen, known by the name of Newcomen's engine.

3*d*, The steam-engine invented by the justly celebrated Watt of Glasgow.

4*th*, The high-pressure steam-engine, invented by Travethic.

As the principles of hydraulic and steam-engines, with their general application, are treated of under the articles Hydraulics and Steam-Engine, these heads are referred to for minute information; and therefore we shall only give a very short account of the engines used in the draining of coal mines, making such practical remarks as have arisen from seeing them applied to work.

The hydraulic engine now in use, seems to have been introduced into the mining operations of England about the year 1680, and into Scotland about theyear 1712; it was an improvement upon the chain and bucket engine, moved by a water-wheel. Several of the present hydraulic engines have wheels 30 feet diameter, and four feet wide in the water-buckets; the cranks are generally from two feet and a half to three feet and a half in length, and are fixed upon each end of the axle or journal; there are two beams of wood placed upon a pillar-head or frame of wood; each beam is about forty feet in length, three feet thick, and two feet broad at the centre, tapering towards the end, and firmly bound together with iron glands, and, to prevent them bending, they have each a king-post and martingale stays; one of the beams is attached to the crank on one side of the axle by a connecting rod, and the other beam is connected in the same manner to the crank on the other side of the axle, to the other ends of the beams which project over the pit mouth, the spears or pump-rods are attached, which work in the pumps. If the pit is from 20 to 30 fathoms in depth, then two piles or sets of pumps reach from the bottom to the mouth of the pit, where they both deliver their water; if the pit is from 30 to 60 fathoms in depth, then the depth is divided. One set of pumps reaches from the bottom to half way up the pit, where the water is delivered into a cistern, from which cistern the upper set or pile of pumps reaches to the top of the pit, where they deliver the water. This machine is of very simple construction; the working parts are few, and requires no attendance—it places a coal-field drained by it nearly upon as moderate a footing in point of expence as a coal-field which is *level free*, and in some instances even upon a superior footing. Many attempts have been made to improve this engine, and to render its powers more efficient, but without success.

Newcomen's atmospheric steam-engine being of very simple construction, is still generally used as a pumping engine in collieries, when the kind of coal used in working them is of little or no value, and when the depth does not exceed 120 yards; for a greater depth, and where pumps are used above ten inches diameter, the improved engine of Watt is preferred.

The steam-engine invented by Watt, known by the name of Watt and Boulton's engine, applied in draining collieries, is of two kinds, named single and double power engines.

In the single power engine, the cylinder is close at the top, and has the steam operating against the piston, as it descends, by means of the vacuum formed below it. This engine, like Newcomen's, only draws water by the descending stroke of the piston; but with much greater power, that is, a much smaller cylinder is required to produce the same effect.

In the double-power pumping engine of Watt and Boulton, the piston acts with equal force, whether ascending or descending, so that an arrangement altogether different is required for working the pumps, because one half of the pumps in the pit is worked by the descending, and the other half by the ascending of the piston in the steam cylinder.

Both the single and double engine of Watt have been applied in a different manner from that before stated; it had occurred to colliery engineers, that it would be a great improvement in the pumping steam-engine, to throw aside the great and massive lever beam, which in some instances exceeded ten tons in weight. This plan was accomplished by placing the cylinder in a perpendicular direction, directly over the pumps above the pit mouth; but this plan has not succeeded. It appears that nothing has been gained by laying aside the great lever beam, weighty as it is, because, when well constructed, very little power is required to move it.

Trevethick's engine is of unlimited power, with regard to the pressure upon each square inch of the piston. As it operates by means of steam raised to a great elastic power, it is employed either as a single or double engine, in the same manner as the engines of Watt. They were first applied to collieries in a very simple form, by allowing the steam, which had acted by its pressure on one side of the piston, to escape into the air, while the elastic steam acted on the opposite side of the piston, and so alternately. Mr. Woolf has applied the highly elastic steam principle of Trevethick to the principles of Watt's engine, and these engines of combined principles are now much used in draining the very deep and heavily watered mines in Cornwall. Some of these engines work with a pressure of more than four atmospheres on the square inch of the piston, that is, more than 60 pounds upon the square inch; but they are not in general use, as a considerable degree of danger attends them.

With respect to the general range of the power of the different kind of engines before described, mining engineers are in the practice of calculating their powers according to the weight of the column of water raised from the bottom to the top of the pit, independently of friction, and the *vis inertiæ* which has to be overcome at each incoming and returning stroke, at which points the whole power and movement of the pumping engine must be brought to rest, and the direction of the power altered.

The winnings or fittings of collieries are of various depths, from a few to two hundred fathoms, which is the deepest winning in Great Britain, that is, the deepest at which coals are wrought; but the deepest coal-pit is only one hundred and fifty fathoms. The depth of any winning or fitting is made to correspond with the capital to be employed, and the vend or sale of coals which may be calculated upon, according to the state of the demand for coal; it being very evident, that a very limited vend will not, at the ordinary rate at which coals are sold, admit of a great capital being invested in making a winning, either by a day-level or by machinery.

The depth of the winning having been determined upon, the manner in which a winning is made by a day-level has been described. We have now to state the manner in which a winning is made by machinery.

The depth at which the coal is to be won regulates the power of the engine to be applied, having in view the probable quantity of water which may be found, which last regulates the width of the working barrel of the pumps. In a district of country where coals are working by means of numerous winnings, the quantity of water which is likely to be found in a new winning may be estimated from what is found in the other works adjoining; and it has been found from experience, that even in opening up collieries in new districts of coal-fields, the water found in sinking is generally such as can be drawn by pumps of from ten to fifteen inches diameter, excepting in cases where the strata are connected with rivers, sand-beds full of water, or marshy ground.

In cases where feeders of water proceed from rivers or sand beds, they can be prevented from descending the pit, and therefore the growth arising from these sources needs not be taken into the calculation of the water to be drawn; and it is found in sinking pits, that although the growth, which cannot by any means be prevented from descending into the mine, may be very great, and even so great as to exceed the power of the engine for some time, yet, as the extra flow of water frequently proceeds from the drainage of fissures, these gradually abate to a moderate quantity. An engine having eight or ten hours work drawing water each 24 hours, is reckoned moderate and comfortable for a new colliery. In the course of years, as the workings advance, many fissures are cut, and as the coal is excavated towards the crop, and approaches the alluvial cover, a constant increase of water is found, so that a colliery which has been long at work frequently becomes very heavily loaded with water, and the machinery is required to go night and day. When a colliery is thus loaded with the ordinary daily growth of water, its situation is rendered dangerous and uncomfortable, to obviate which, the power of the engine is either increased, or additional engines erected. In practice, working barrels are seldom used of greater diameter than 18 inches, and in place of having pumps so large, many of the mining engineers prefer having two engines with less powers, and moderate sized working barrels, on account of the unwieldy nature of such heavy machinery, and the great extra tear and wear attending them.

The extent of the winning to be made, as to depth, and the power of machinery to be employed, having been determined upon, the mode of sinking engine pits has next to be described.

First, When the depth is moderate, and the process comparatively very simple.

Second, When the depth is great, and the process laborious and intricate.

In any winning, the figure of the engine pit is a primary consideration. In winnings of a moderate depth many forms are used, as circular, oval, square, octagonal, oblong rectangular, and long-elliptical.

In pits of inconsiderable depth, and where the alluvial cover is of a firm and dry consistency, any shape thought the most convenient may be used; but in all deep pits, no shape but the circular ought to be used. Indeed, when water requires to be stopped by tubbing or cribbing, no other shape will do, the circular shape being the only one which presents a uniform resistance in all points to the uniform and great pressure of water—even the elliptical shape, where there is but little difference between the two diameters, is not suitable; it has been tried, and has always given way when exposed to pressure of any considerable degree. Besides, the circular shape renders the pit stronger in the shaft walls, and is likely to be less injured than any other shape, in the event of the shaft being shaken by a sit or crush arising from the failure of the pillars left in working the coal. As to the sizes of engine pits, the smallest should be ten feet diameter, to admit the pumps to be placed in the lesser segment, and the coals to be drawn at the larger one, as in Plate CCCXC Fig. 9. which is termed a double pit; but if much work is to be done in drawing coals, and particularly if the coals are large, it would be an economy to have the pit wider than ten feet. When a pit is to be divided into three divisions, one for the engine pumps, and two for drawing coals, as in Fig. 10, which is termed a triple pit, it would require to be twelve feet diameter. If it is to be divided into four divisions, and made a quadrant pit, as in Fig. 11. with one division for the pumps, and three divisions for ventilation and coals drawing, it would require to be fifteen feet diameter. These sizes of pits are regulated by local circumstances, and by the output of coals proposed to be raised.

In sinking engine pits, the first point is the mode of passing through the alluvial cover. If it is of a firm and dry consistency, the process is easy, whether the depth be great or not. As all engine-pits require to be particularly well executed, and every part of the work done in a substantial manner, the shaft which passes through the alluvial cover ought to be secured with masonry of jointed ashler, with the joints accurately bevelled to the centre of the circle which forms the area of the pit. The stones used are from a foot to sixteen inches in thickness, about a foot in depth, and of any convenient length. The pit is therefore begun, and sunk of a circular form, through the alluvial cover, of such an extra width as to admit the thickness of the masonry or stone cradling, as it is termed. When the depth is about 12 or 15 feet, the bottom is made level, and a ring or crib of oak or elm, about four and a half inches thick, and ten inches broad, laid in the bottom. Upon this the ashler is built upwards to the mouth, and all the void betwixt the ashler and the earth walls firmly beat up with clay. The next operation is to sink again, keeping the sides about three inches inside of the perpendicular of the ashler walls. This sinking is carried down from three to nine feet, according to the consistency of the cover, and when the distance is fixed upon for another crib, the pit is widened out at the bottom, so as to admit the second crib to be laid exactly in a perpendicular direction below the other; and when this crib is laid in its place, about three or four feet in breadth is taken out from one of the sides, and in this a pillar of ashler is built, resting upon the lower crib, and supporting the upper one. The same thing is done on the side immediately opposite, and then at the other quarters of the circumference, after which the intermediate spaces are widened and built up. In this manner the pit is sunk until the rock head is found, when it is made level, and the lower part of the ashler rests upon it. When stones cannot be easily procured, hard bricks are substituted, ten inches or a foot in length, with a level to suit the radius of the pit. When ashler is built in stages, as before described, the under building may be sometimes done with three pillars, and then filled up around; but when no cribs are used, as is sometimes the case, very narrow pillars are built up, to secure the masonry above.

When the cover is not very firm, the stages sunk at a time, and built up with masonry, will not admit of being more than from two to three feet, and when the cover is of such a kind as not to admit of this mode of operation, a different plan must be adopted.

If the cover is of clay, with sand backs and oozings of water, so that it will not stand firm for even a foot or two, it may be sunk through, and secured by the following process.

For circular pits, circular fellies of wood, named cribs, and for square or octagon pits, square balks of wood, named bars, are prepared, and used as a temporary cradling until the mason-work is built. The width of this carpentry depends upon, whether the timber is to be drawn out as the building advances upwards, or if it is to be allowed to remain, and the mason-work built within it. The shape of the pit where the timber is used is either a circle, a square, or an octagon. The temporary cribs are formed of oak, ash, or elm, about seven inches in the bed, and five inches deep. The balks are of fir, and from six inches to a foot square, according to circumstances. The joints of the circular cribs are plain, and bevelled to the radius of the circle. The joints of the balks for a square or octagon pit are half checked.

If the timber is to be left in the pit, and the masonry built within it, the quality of the wood need not be much attended to; but if it is to be drawn and used again, it requires to be good, in order to bear the fatigue it is exposed to, without being rendered useless.

With circular cribs of wood, backing deals are used of about 1¼ inches thick; the pit is then sunk as far as the cover will admit with safety; a strong crib is placed at the top or pit mouth, in a level position; the backing deals are placed all around, and reach to the bottom of the space sunk; cribs are then placed about two feet apart, and the lower crib of the set is fixed the half of its depth lower than the ends of the backing deals; the cribs are secured at the joints by thin spars of wood overlapping them, and they are kept in their horizontal position, either by brackets placed under them, and nailed to the backing deals, or by a few deals placed inside of the cribs, and nailed to each. Particular care is requisite, in sinking through the cover, to have it no wider than necessary, in order that the backing deals may bear against it, and if there are any vacuities, these must be filled up with rubbish well packed. When the first or upper space is thus secured, another space is sunk, of such a depth as the cover will admit of; then backing deals and cribs are placed in the same manner as above described, the end of the second set of deals having a hold of half of the lower crib of the first set. In this manner is the cover sunk through and secured, until the rock head is found, when the masonry is begun, and carried upwards to the top; if the cover is of such a kind as to admit the cribs and backing deals to be drawn, these are taken out in such lengths at a time as are judged safe, and the space betwixt the masonry and cover filled up with any kind of rubbish, firmly beat in. If there is any risk of the cover slipping, then the carpentry, or the greater part of it, must be allowed to remain in the sides of the pit.

In sinking square pits through a firm cover, the same kind of process is adopted as that with the circular cribs, the only difference being in the joints, which are half checked.

In sinking through a firm cover with a pit of an octagon form, the bars or balks are half checked in the joints, and put in close to one another; this is termed being placed skin for skin. If the cover is of a very firm consistence, their scantling or dimensions are small; if it is less firm, they are made proportionally strong. The process carried on in sinking to the rock head is the same as before described, the depth of cover passed through and secured, each stage being regulated according to the tenacity of the cover. The masonry is carried upwards from the rock head in the same manner as before described.

It is a common practice to place two strong logs of wood at the top of the pit, parallel to each other, and at a distance equal to the diameter of the pit, resting on cross sills, laid upon the surface of the ground; these are termed the hanging sets. From them the cribs or bars are suspended, and prevented from slipping downwards, by a few planks placed in a perpendicular direction along the face of the bars, and to these planks each bar is nailed.

When the cover is of soft mud, which is a common circumstance in many coal districts, it is passed through either by bars laid close to each other, or, if this mode is not found practicable, the operation of tubbing is resorted to.

When bars are used, each set requires to be put into its place as soon as the pit is sunk the depth of a bar. In this manner the sinking proceeds till the rock head is found, when the masonry is begun and completed as before mentioned. It is necessary to remark, that there is great attention required in this operation; for if the pit is sunk below the last placed bars, and not immediately secured by additional bars, the mud will swell out into the area of the pit, and, when this begins, it is almost impossible to stop it. The consequence of which generally is, that a void is formed at the back of one part of the bars, the resistance is then lessened, and the pressure operating powerfully on the opposite side, the bars give way, and the pit is frequently lost. It is also found necessary, sometimes, before a bar can be placed into one side, to drive a row of thin sheeting piles, from three to four feet long, into the mud upon the other sides in face of the bars, which prevent the mud coming into the pit while the other bar is fixing; and when this bar is placed, one side of the sheeting piles is removed and driven at the face of the last placed bar, till the adjoining bar is fixed. In this manner the bars are placed progressively.

When the mud is found to be so very soft that the operation of tubbing must be resorted to, a circular tub is formed of the requisite diameter. It is made of plank, from two to three inches thick, with the joints bevelled to the radius, inside of which are cribs of hard wood, placed at from two to four feet asunder, according as the circumstances of the case may require. The cribs are made of the best heart of oak, sawn out of the natural curve of the wood, suitable to the radius, in segments of from four to six feet in length, from eight to ten inches in the bed, and five or six inches in thickness. The reed of the wood require to be clean, without any twist or cross grain, for the greater strength and security of the work. The length of the tub is made from nine to twelve feet long, if the mud is of that thickness; but if the mud is very thick, a succession of tubs is placed one above another. The tub first to be used has the lower end of the deals made thin all around, and shod with sharp iron in the face. If the pit is previously secured to a certain depth, then the tub is constructed to pass within the cradling, and lowered down with tackles till it rests among the soft mud, it is then loaded with iron at the top, so that it may sink as the mud is excavated. If the first tub does not reach to the rock, then a second tub of similar construction is placed upon the top of it, and the iron weights removed also to the top. In this manner the tubbing is sunk, till the cover is passed through and secured. If the mud is uncommonly soft, and pumps are used to draw the water, they must be hung with tackles, and not allowed to sink down so low as the bottom of the tub, as they would not only be liable to choke, but they would have a tendency to draw the mud from the back of the tubbing. It is therefore the practice to keep the bottom of the tub several feet in advance of where the workmen stand, and to keep about a foot of water upon the top of the mud. In this way the workmen stand upon pieces of board, to prevent themselves from sinking; and the mud is lifted with scoops or shovels under the water. If the mud is of great depth, the tubs must be strengthened with additional cribs to resist the pressure.

The most difficult operation in sinking, is when the cover has a bed or beds of quicksand in it, or has a great bed of quicksand from the surface to the rock head. This circumstance is, in all cases, productive of great additional labour and expense. In the early times of mining, a quicksand cover formed an insurmountable obstacle to the miner; and it is only within the period of a few years past, that the operation could be gone into with the hope of ultimate success. As this is one of the most important points in coal mining, and as very large sums have been lost by unsuccessful attempts to sink through the sand, the different processes which have been adopted, and most approved of, will be now described, so that a distinct idea may be formed of them.

In sinking a pit through any cover, the nature of which is not known, the first thing to be done is to prove it by boring; when that is done, the plan of operation most suitable can then be determined on.

Beds of quicksand are frequently found covering coalfields upon the margin of the ocean, or by the sides of rivers. One of the oldest plans for passing through them, is by what is termed casting out; this is still practised successfully. If the sand lies close to the surface, and does not exceed sixteen feet in depth to the underlying bed of clay or the rock head, the plan of casting out is adopted; if it is deeper than this, another process is required. When the depth is about sixteen feet, the first operation is to bring up a surface drain, as low as the situation will admit of, which, in most cases, from the flatness of the surface, is very little; then from the point where the centre of the pit is to be, a circular area is marked off, of such a width, that if the pit is to be twelve feet diameter inside when finished, the sand may be excavated in the form of the frustrum of a cone, having the sides sloping at an angle of 45 degrees, which slope is set off at such width as to uncover the impervious clay or rockhead to the width of twenty feet. In this case the mouth of the excavation would be about 52 feet in width. It is of great consequence to carry on this operation very expeditiously; in some instances from fifty to a hundred workmen are employed, and as much of the sand as possible is taken out by horses, carts, and barrows, and laid at a distance. As soon as the water begins to gather, sloping pumps are used, and the water never allowed to accumulate. When the slope renders the using of carts and barrows no longer convenient, then the sand is thrown out by various means, such as by men from one stage to another, by trams and tramrods laid along the slope, or by common jack-rolls or windlasses, with ropes and buckets erected upon framing supported by tresses. Horse-gins are also used, placed at a distance from the pit; and when the water is very heavy, a small steam-engine is employed; the framing over the excavation being either supported by tresses and stays, or by masts, from which the framing is suspended by tackles. No foundation can be got for the main pumping engine till the pit is built up and the cover made quite secure. If towards the bottom of the slope the water is likely to produce a running of the sand, the slope is carefully covered with compact turf, cut from a green sward, which, though a very simple remedy, is frequently quite effectual if applied in time; for it has been found from experience, that if once the bottom of the slope begins to run, it cannot be stopped in its progress, so that in a short time the whole labour of weeks may be lost. Plate CCCXC. Fig. 12. represents a bed of quicksand resting upon a bed of impervious clay, which clay is the immediate cover of the rock. When in this case the clay is found, the first course of ashler stones, jointed to the radius of the pit, is laid in a true circular position in the centre of the area, and about a foot into the clay; or in some cases where the clay is not very strong, a circular crib of wood is laid down; upon this the ashler is built, and as each course of stones is laid, about a foot or fifteen inches of well-wrought clay is regularly beat all around the back of the building, and whatever water comes from the sand, flows up at the back, and is allowed to run over the building into the area of the pit, in order to be pumped up. As the ashler and moating are progressively carried up, the space at the back is filled up with sand and rubbish, until the pit is completed at the top, and the surface made suitable for the operations of the colliery. By this plan none of the water found in the sand goes down the pit, but is kept back by the clay moating till it finds a natural issue at the surface. A is the pit, *a a* the quicksand, *b b* the excavation afterwards filled up, *c c* the ashler building, *d d* the moating of clay. When this is done, the impervious clay is sunk through to the rock head, and secured with ashler in the manner mentioned for sinking through compact cover. If the sand rests upon the rock head, and the rock be of a kind which is impervious to water, then the ashler is laid upon it as soon as a level foundation is made; but if it is a porous or jointed stone, it must be sunk through until a stratum impervious to water is found, from which place the building and moating commence.

If the quicksand is deeper than sixteen feet, it is thrown out in the first place to that depth, in the manner before described, and the additional thickness of sand is passed through by means of strong frames of wood, at the back of which sheeting-piles are driven down progressively as the sand is taken out; but this mode of passing through sand is uncertain of success, and is not in general practice.

The manner of passing through mud with tubbing having been before described, the same kind of operation is applicable to passing through quicksand; and if the bed of sand is thick, it is passed through by what is termed a drop tub, that is, after a number of tubs have been sunk by great weights, and begin to get body fast, so that they will not sink any farther, another set of tubs is let down through these, and continued till they reach the rock. These tubs are constructed of such strength, as to resist the pressure and be water-tight. If the tubbing is judged to be too weak at the bottom for the pressure, an additional number of oak cribs are inserted. During the operation, the bottom of the tub which is sinking is kept always a few feet lower than the spot where the men are lifting the sand, in order to prevent the sand flowing in from the back of the tubs; and it is necessary to keep about a foot of water upon the top of the sand, and to hang the pumps in such a manner as only to be a few inches into it. When these tubs are completely secured and wedged tight at their junction with the rock head, and where they join each other, the whole internal face of the cribs is covered over with close jointed deals, an inch and a quarter thick, which gives the pit an appearance of a smooth wooden cylinder.

The most effectual method for passing through beds of quicksand is by means of iron cylinders, termed cast-iron tubbing. If the pit is of small diameter, these are made about four feet in length, with strong flanges, and bolt-holes inside of the cylinder, with a counterfort ring at the neck of the flange, with brackets; the end of the lowest cylinder has no flange, but is rounded to render its sinking through the sand more easy. If the pit is of a large diameter, then the cylinders are cast in segments of two, three, or more pieces, joined together with inside flanges, having a jointing of white lead and oakum. If the sand-bed is thick, suppose eighty feet for example, the practice now is, to divide that space into three sets of cylinders, thirty feet each in length, and so constructed as to pass through each other like the tubes of a telescope. These cylinders are joined together, piece after piece, and pressed down by great weights, using the same precautions in keeping the lower part always farther down than the top of the sand where the men are at work, and where the bottom of the pumps is for drawing the water. When the first thirty feet of cylinders is put down, the lower part of the next set of cylinders is passed through the first set, and the sinking carried on until the additional thirty feet of cylinders are sunk, after which the third set of cylinders is passed down through the two former sets, until the lower part reaches the rock-head or impervious stratum; the joinings of the three sets of cylinders are made tight by wedging with wood. It is proper to remark here, that this mode of dividing the deep sand to be passed through into spaces, is an improvement but lately adopted at Newcastle. Before this improvement, almost every attempt to pass through very thick beds of quicksand was rendered abortive.

The engine-pit being thus secured by one of the several ways before-mentioned, the process of sinking through the rock is now ready to be begun; but, before commencing, the divisions of the pit formed of carpentay, named brattices, are made; this is done in several ways.

In common practice, and where great tightness of jointing is not required for ventilation, on account of inflammable air, bars of wood, named buntons, of about six inches thick and nine inches in depth, are fixed in a horizontal position across the pit; they are placed at different distances according to circumstances, sometimes at the length of a pump from each other, and at other times there are two or three in that space. These buntons, are all placed in the same perpendicular line, and upon these, deals of an inch and half thick are nailed, having their joints close; and each length of these deals takes in the half of the upper and under bunton to which it is nailed. In deep pits, when the ventilation is to be carried on by the brattice, the side of the buntons next the pumps is covered with deals in the same way, the joints made as tight as possible, and next the pit the irregular joining is caulked with oakum, and fillets of wood fixed all the way down on each side of the brattice; this forms a double pit.

When a pit is divided, so as to form three pits, it is a more difficult process to form the brattice, as none of the buntons stretch across the pit, the three which form the divisions meet, forming angles with each other near the centre of the pit; and in order to give them stability and strength in their position, they do not lie across in a horizontal line, but have a rise from the sides to the centre of about nine inches where they meet, and a three-tongued iron strap binds them together by means of a bolt at each tongue. Fillets of wood are carried down the whole depth, not only at the joinings of the brattice with the sides of the pit, but also at the meetings of the brattice at the centre of the pit; and, for farther security, a prop of wood reaches from the centre of one set of buntons to the centre of those immediately above; by this means a very strong piece of carpentry is formed, having its strength depending upon the principles of the couple of a roof. These buntons are clad on all sides with deals from top to bottom; and the ends of all the deals meet each other in the middle of a bunton.

In quadrant pits the buntons cross each other in the centre of the pit at right angles, and are generally only let in about an inch into each other, in place of being half checked. Plate CCCXC. Fig. 9 is a double pit, A the engine pit, B pit for drawing coals; Fig. 10 is a triple pit, A the engine pit, B and C pits for drawing coals; Fig. 11. is a quadrant pit, A the engine pit, B the pit for the ventilating furnace, C and D pits for drawing coals.

These methods now described, being such as are used in the practice of mining when sinking through the cover, securing the sides of the pit, and dividing the pits by brattices, it must be remarked, that several of these processes are attended with such immense expence, that it is only in districts where great returns of profit are made, that they can be attempted. It is at Newcastle and Whitehaven where by far the greatest capitals are employed, and where the very expensive methods of sinking through quicksand are adopted and prosecuted with vigour and success. As engine-pits are now sunk in winnings of collieries made from the depth of 20 to 150 fathoms, that is, with pits having one set of pumps, to those having five sets, the operation, though in most of the circumstances the same, is very different as to labour, difficulties, expences, and skill required. In winnings of a moderate depth, if the water found in the cover is kept from descending the pit, the feeders found in the rock are allowed to flow down. In deep winnings, the most minute attention is paid to prevent any water from descending, by methods to be described afterwards.

As 75 fathoms is reckoned rather beyond the average depth of winnings or of engine-pits in Great Britain, and as in practice it embraces three sets of pumps, by describing this operation, we describe also the more simple winnings of one and two sets.

As soon as the pit is sunk to such a depth that the engine must be applied to pump the water, the first set of pumps is let down the pit; these are termed the sinking set, they are jointed with strong flanges and bolts, having a jointing of lead of about half an inch thick, covered with tarred flannel. There are several methods for suspending them during the process of sinking, as they must rest on the bottom of the pit, and be lowered gradually as the rock is blown up and wrought away. The common practice in pits with one or two sets of pumps, and where the sets are of no great size or weight, is to have two shroud-laid ropes or cables, named ground ropes, of abundant extra strength to meet casualties and heavy strains. These ropes are made fast below the clack-seat door, and are passed up each side of the pumps, having a piece of service or lapping put round them, opposite to each flange, to prevent their being chafed or cut; and a strong lashing of pliable hand line acts as a collar at each pump, which connects the whole pile firmly together. The ropes are sometimes passed over two large pulleys at each side of the pit mouth, and several turns are taken round a strong circular post of wood, fixed deep and firmly in the ground. As the pumps sink down, the ground ropes are slacked off or eased away, care, however, being taken to keep a considerable bearing upon them, so as to have at least a fourth or a third of the weight suspended; this is a very rude and a very old plan, though still in practice. This method is greatly improved by having strong five-fold tackles attached to the top of the ground-ropes, and the fold of the tackles passed round the post as above described; by this plan the lowering is not only performed more correctly and easily, but the pumps can be lifted up immediately by applying the tacklefolds to crabs or capstans. In this process a caution is necessary while the pumps are lowering, that their flanges do not catch any of the timber-work in the pit, as the weight would not only break them, but endanger the lives of the men at the bottom.

But the most complete and correct plan for lowering the pumps in sinking, is the following, which was practised and brought into use by the Newcastle engineers. There are attached to the wind bore, or suction piece, two very strong ears, (see Plate CCCXCI. Fig. 1.) having counterfort brackets upon the upper side; in each of these is a square hole, three and a half inches diameter, through which rods of iron are put and secured by a strong cotter at the under side of the ear. To these rods, U plates are attached; these plates are fixed to wooden spears, six or seven inches square, according to circumstances, and are connected together with side plates, in the same manner as pump spears. These spears are carried up the sides of the pumps, and close to the flanges, until they are as high as the top of the sinking set of pumps, or a few fathoms higher. Under each flange of the pumps, a lashing of pliable rope is passed round both the spears and the pumps; this keeps the whole very firm and in a perpendicular direction. To the top of the spears. U plates are fixed, having a large strong eye at top; to each of these eyes, a five-fold tackle is hooked, and the upper blocks or pulleys are suspended from strong wooden beams at the top of the pit. The tackle-folds pass upwards from the lower pulleys, over single pulleys at each side, and are hove upon capstans till there is an equal bearing on both tackles. To the arms of the capstans, sledges are attached with ropes or chains; these sledges are loaded with weights in proportion to the weight of the column of pumps, and as additional pumps are added, more weight is put into the sledges. By this very correct and mechanical arrangement, the sinking set of pumps, in the most gradual manner, and of their own accord, sink as the pit is sunk, and draw round the capstans. Before this method was adopted, the trouble, loss of time, and danger attending the lowering of sinking sets, were uncommonly great. As the sinking set is constantly going down, and the point for the delivery of the water always varying, a pipe of the same diameter as the pumps, but much lighter, is used, about eleven feet long, having a short pipe cast near the top, to which a hose or hoggar of leather is attached, of sufficient length to reach the cistern where the water is delivered. This is called the hoggar-pipe; and in the course of sinking, as soon as the top of the hoggar is upon a level with the top of the cistern, the hoggar-pipe is removed, a common pipe put in its place, and upon the top of this pipe the hoggar-pipe is again fixed. In this manner the operation of sinking goes on, until the column of pumps has reached either the bottom of the pit, or the place fixed upon for having another set of pumps. A, is the sinking set of pumps, *a*, *a*, the ears through which the iron rods pass connected with the spears; *b*, *b*, the spear; *c*, *c*, the lashings; *d*, the hoggar-pump; *e* the hoggar; *f*, *f*, the tackles; *g*, *g*, the single pulleys; *h*, *h*, the tackle-fold leading to the capstans; *i* the pump spears.

In a sinking set of pumps, the wind-bore or suction-piece, is not open at the bottom as in the other sets, which are fixed, but it is rounded and of a long form; it is perforated with holes of from one to two inches diameter, where, besides the small holes, there is a large hole for admitting a man's hand, in order that the cavity may be at any time cleared of rubbish which may gather within it. When the workmen are sinking, the large hole is filled with a plug, having a projection of such length as renders it easily drawn at any time; the workmen have a number of plugs for the small holes, and when the operation of sinking begins, the upper tiers of holes are plugged up, and the ingress of the water confined to the lower holes. By this plan, as the bottom of the suction-piece is kept in the bottom of the sump, or lowest part of the pit, the other part of the pit bottom is kept dry for the operations of the workmen. If the growth of water abates, more holes are plugged up; if it increases, an additional number of them are opened. When the operation of sinking is suspended for any time, all the plugs are withdrawn in order to give full water way to the regular working of the engine; and as much depends upon keeping the suction-piece safe, where it is exposed to violent strokes from the blowing up of the harder rocks, it is necessary either to wrap it round with old ropes, or to case it with staves of soft wood, which will not easily split. It is further to be observed, that as in sinking, a vast quantity of air enters with the water every stroke of the engine, the pumps are filled with air and water together. On this account, the engine is wrought upon air, as it is termed; and it is the object of the engine-keeper not only to make the lifting stroke very slow, but so to regulate the movement, that when the stroke is completed, the engine may stop several seconds before it makes the returning stroke, to allow all the air to ascend. If the engine is working as a double power engine, the same kind of halt must be made at the returning stroke. This mode of working the engine is now regulated either by water cataracts, or by air vessels attached to the gear of the engine; or in small engines, the working is regulated by a man upon the hands of the engine, when the improved regulators are wanting. As the working barrels are generally nine or ten feet long, and the full stroke of the engine from seven to eight feet, when at regular work, it is the practice to lessen the length of stroke in sinking to about six feet, because, as the pumps are constantly going down, the bucket in the working barrel progressively has its working space higher up. If the working barrel is ten feet long, and the restricted stroke of the engine six feet, and if the bucket is at the bottom of the barrel when the engine is ready to make its stroke, then the pumps can be lowered about four feet, ere the bucket be working at the top of the barrel. To this descent of the pumps particular attention has to be paid; and therefore, as soon as the pumps have sunk four feet, the spears and bucket are let four feet lower into the barrel, and this is done at the top of the pit, when the spears overlap, and are fixed laterally by screwed glands.

The common depth for a set or column of pumps being from 25 to 30 fathoms, when this depth is attained by the first set, preparation must be made for fixing the upper pit cistern, into which the upper set of pumps is to be placed, and into which the water of the second set is to be thrown. If a strong bed of sandstone is found, a scarcement is left of the rock projecting about three feet into the pit, and is formed, in the course of sinking, into a chin or strong bracket, to support that part of the cistern upon which the upper set of pumps is to rest; and a few feet under it, the pit is formed into its regular width. A recess is cut into the side of the pit backwards from the bracket, for holding the cistern into which the upper set of pumps is to be placed. For the greater security of the place where the pumps rest, the recess is formed dove-tailed, about eleven feet back from the face of the bracket, from three to four feet in breadth, and about thirty inches in depth. Into this, a pit cistern bunton is laid and firmly wedged, composed either of oak or of best foreign redwood pine, having the thick end laid into the back part of the recess, to prevent its coming forward into the pit, by the concussions and vibrations of the pumps, and in case of any failure of the bracket under the pumps. The inner end of this bunton is farther secured by blocks or chokes of wood, placed betwixt the upper side of the bunton and roof of the recess; similar chokes are placed upon the inner end of the cistern. When the rock is of such a quality as not to be fit for forming a bracket, then a cross bunton of wood is substituted, from one to three feet in breadth, and from two to four feet in depth, according to the weight of the column of pumps to be supported. This bunton is fixed into the sides of the pit, and has a hold at each end from two to four feet, according to the strength of the rock; upon this the cistern is placed, having a recess, as before described; sometimes logs eight inches thick are placed into the recess, at right angles to the cross bunton, firmly secured together, and upon these the cistern is placed.

Although from 20 to 30 fathoms is the common length of a lift or set of pumps, it sometimes is necessary to make it much longer, when no place can be found in the shaft for fixing a cistern, on account of the tubbing; from this cause a lift of pumps has been made of 70 fathoms in length; but this requires uncommon strength of every material, and such a length is only made from absolute necessity.

It is the practice to use the sinking set of pumps for sinking the whole depth, so that as soon as the first cistern is ready, a set of pumps, named a fixed set, is substituted for the sinking set. In common practice, fixed sets of pumps are joined together by flanges and bolts, but in the improved practice, all the fixed sets have spigot and faucet joints; and the joints are made water tight by lappings of tarred flannel. But the lower set of pumps of every engine has flange joints, with strong bolts, for the special purpose of their being connected in one firm column, so that if the water should grow up the pit, or any leak happen in them below water, the whole may be drawn up from the bottom, if necesssry, and repaired; which operation could not be effected with the other kind of joints, as they would not hang together. In the case where there is only one lift of pumps, the flange-joints are for the same reason used. The spigot and faucet joints render the drawing of pumps one by one, and placing and jointing them, a much quicker operation than when the other joints are used. In general, the operation may be performed in less than a tenth of the time required for the other kind; and it may be frequently of great service to have the upper half of the lower set with spigot and faucet joints, if there is no risk of the water rising very quickly up the shaft, of which there is generally little danger after the colliery is opened up and a sufficient reservoir formed for the water.

With regard to the mode of collaring the pumps in the pit, keeping them steady, and in a true perpendicular line, the old practice is, to have two buntons of about nine inches deep, and six inches in breadth, to pass close to the side of each pipe under the flange or joint. The ends of these are fixed into the shaft wall, and the other ends rest on brackets fixed to the brattice wall; the other sides of the pipe are collared by pieces of wood, named rackings, and in some cases stretch only the breadth of the buntons; or, if the pit admits of it, one or both of them are fixed into the side of the shaft wall. The improved plan, in order to give as much room as possible for the operations which are so frequently carried on in the engine pit where the pumps are, is to fix a strong bunton under the joint of each pipe; to which buntons the pipes are firmly attached by a collar of iron, with screws and nuts, as represented Plate CCCXC. Fig. 13. By this plan there is much more room in the pit.

Though this mode of fixing the pumps is very suitable for all the upper sets of pumps, it is not so for lower sets, where from accidents to which they are liable, the pumps are sometimes to draw up bodily. The mode of fixing with buntons and rackings is therefore preferred in the lowest set, and the fixtures are so made, that if there is not time to remove the buntons and rackings, the whole may be hove up. In cases where the buntons hold fast, they must be cut away under water by chissels fixed upon loaded spears.

With regard to the water which is found in sinking through the several strata, in ordinary cases it is conducted down the walls of the shaft. If the strata are of a firm consistency, a hollow ring is cut into the sides of the pit in a spiral line down the shaft, and when the ring can hold no more water, the water is either conducted down in a square spout to the nearest pit cistern, or a groove is made in a perpendicular direction in the shaft wall, and a squere box either inserted into it, flush with the sides of the pit, or it is covered with deal fitted tightly to the cavity. Similar spiral rings are formed in succession downwards, and the water conducted always into the nearest pit cistern. The improved plan is, to insert rings of wood or cast iron, flush with the sides of the pit, and the water is conducted from one ring to another, by means of perpendicular pipes, until the under ring can hold no more water. When the water from that ring is carried in pipes to the nearest cistern, then a new set of rings is inserted under these, and the water conducted in the same manner all the way down. As keeping a pit dry is an important point, great attention is paid to the doing of it well. When it happens in an engine-pit that there are a great many beds of coal found in the shaft, a mine a few yards long is driven into each coal, and a bore put down from one coal to another, the water is gathered into each coal, and descends through the bores to the pit cisterns.

The practice of keeping the shafts dry, as now described, is very generally adopted in Great Britain, when the pits are of a moderate depth, and when all the water found in sinking can be drawn by an engine of a moderate power. But in very deep pits, such as those in the counties of Northumberland, Durham, and Cumberland, where they are from 80 to 150 fathoms in depth, the preventing of the water found in sinking, from being a burden upon the engines, is most carefully attended to, and is one of the chief points in the science of mining. In this operation, much skill and resolute determination are displayed. The mode of passing through the cover, and the various modes for preventing the water from that source descending into the pit, have already been described. The next thing is, to point out the plans which have been successfully adopted for preventing the water found in sinking from flowing into the pit, and becoming a burden upon the engine. Those strata which generally produce the greatest feeders of water, are the sandstones, particularly those of an open porous texture, or those which have very open cutters. Sometimes both these qualities are combined, and then the growth of water is uncommonly great. Several of the sandstones are, however, impervious to water, and almost all the beds of light-coloured argillaceous schistus or fire-clays are particularly so, being very close in their texture. But some of the sandstones, though impervious to water in their texture, have wide and open cutters which produce much water. Feeders of water are also frequently found at the beds or partings betwixt two of the strata. Those strata which are impervious to water are said to be capable of turning water.

While the sinking of one of these deep pits is going forward, a regular journal is kept of every part of the operation, and each feeder of water is measured, not only after it is found, but daily, to find if its growth increases, abates, or is regular. The mode of measuring is by receiving the water into a vessel of 30 or 60 gallons content, and finding, by a seconds watch, the time required to fill it. Three experiments of this kind are made at each trial, and the average time of the three entered in the journal. When the feeders of water in one or more of the strata sunk through are producing such a quantity of water, as to render the stopping of it back absolutely necessary, the first thing to consider is, whether any of the strata passed through under the feeders are impervious, or capable of turning water; and if there are none, the pit must be sunk till a stratum of that kind is found; then the strata are to be examined upward, until a similar stratum is fixed upon. There are three methods of keeping back the feeders; viz. by plank tubbing, iron tubbing, or by oak cribs. As the pressure to be resisted is the next consideration, it becomes necessary to explain its extent or limits. To illustrate which, Plate CCCXC. Fig. 14. represents a pit sinking through the various strata, having a cover of sand with much water resting on the rock head. It is evident, from what was explained when treating of the forms of coal-fields, that each stratum sunk through in any pit, whether near the surface, or at the greatest depth, rises in one direction until it meets the alluvial cover; for which reason, the pressure of water at the bottom of the tubbing which rests on the rock-head, is as the depth of the water found in the cover; and if a stratum *a* is found to yield a great quantity of water, and that the stratum *b* above, and the stratum *c* beneath it, are impervious to water, if the porous stratum *a* is twelve feet thick, and no water found in the strata passed through from the rock-head, until that depth which is supposed to be fifty fathoms from the surface of the water in the cover, in this case, the tubbing or cribbing has not to resist the pressure of the water of twelve feet only, but must be made of strength sufficient to resist a column of water equal to a perpendicular altitude of fifty fathoms; because the stratum *a* meets the alluvial cover at *d*, the fountain-head from which all the water found in sinking proceeds. Upon this principle, though no feeder of water was found of any magnitude until the pit had been sunk 100 fathoms, if this water required to be tubbed off in a stratum only three feet in thickness, the tubbing would require a strength equal to the resisting of 100 fathoms of pressure; for although the water may only come through the open pores of the stone, yet, when the water is resisted, these innumerable tubes act upon the tubbing with the full effect of the whole hydrostatic column; for it is found from experience, that whatever water occurs in pits, or in the working of mines, proceeds from the surface. A clear understanding of this principle is an essential point in mining. Upon this principle, also, if the cover which rests upon the rock-head is of impervious clay, very little water will be found in the strata; but if sand beds rest upon it, or rivers run along it, the water will be very abundant.

From this view of the great pressure of water found in sinking, the tubbing it off is an operation of the first consequence, and requires much skill, attention, and practice. If several fathoms of the strata are to be tubbed, in order to resist the flow of water, the pit has to be widened regularly, to admit the kind of tubbing proposed to be put in. The greatest width being required for plank tubbing, and the least width for iron tubbing. Plate CCCXC. Fig. 15. represents a pit widened out for plank tubbing, where *a*, *a*, *a*, *a*, are the impervious strata, *b*, *b*, the porous strata yielding the water, the bottom of the recess *c*, *c*, is made level, and as smooth as possible, by means of mason irons. The same points are attended to in working off the upper part of the recess *d*, *d*. In this operation, wedging cribs, spiking cribs, and main cribs are used; besides the plank which forms the tub, a quantity of fine dry clean reeded deal is prepared for forming the joints, which is known by the name of sheeting deal. This sheeting deal is always applied in pieces laid end-ways; that is, with the end-reed of the wood towards the area of the pit. As much of the security depends upon the tub being water-tight at its jointing with the rock, several plans have been adopted for this purpose, the most approved of is represented, Fig. 2. Plate CCCXCI.

In order to give room for the lower wedging crib, the recess is cut a few inches wider, as at *c*, from *b* to *c* is laid with sheeting deals all around the circle, or with a thin uniform stratum of oakum. Upon this the wedging crib *d* is laid, and neatly jointed to the radius of the pit, each segment trained exactly to the circle. At each joint of the segment sheeting deal is inserted. This wedging crib is about ten inches in the bed, and six inches deep. The space *e*, at the back of the crib, about two and a half inches wide, is filled with pieces of clean reeded dry deal, inserted end-ways: and this is regularly wedged with one set of wedges all around; then with a second and third set in the same regular manner, the object being to keep the crib in a position truly circular, the wedges used in this operation are made of dry clean fir, very thin at the head in comparison with their length, openings are made for entering the points of these wedges by a steel wedging chissel; and the wedging is continued regularly around, until the steel wedging chissel cannot make an opening in the wood. By this operation no water can pass downwards by the back of the crib. The next operation is, to fix a spiking crib, *f*, to the rock, about 10 or 12 feet from the lower crib, according to the length of the planks to be used for the tubs. This spiking crib is about five inches square, and is only used for spiking the deals of the tub to it. They must, however, be set true to the sweep of the pit, as upon them the true circular figure of it depends. This spiking crib being placed, the tubbing deals, *k*, are to be fixed. These are made of deals three inches thick, and about six inches broad, planed on all sides, and the joints wrought to the true bevel of the circle of the pit. Sheeting deals are laid under the deal ends, and the tub deals are firmly set together, one by one, in a perpendicular direction, their upper ends reaching to the middle of the spiking crib *f*. Formerly these planks were fixed to the spiking cribs with iron nails or spikes, but as these were soon destroyed by corrosion, particularly when there was any salt in the water, treenails are now used, and found to be much better. When the planks are set around, and within less than three breadths of a plank from being closed, a plank is placed on each side of the opening, having a square joint next each other in place of being bevelled, which leaves a rectangular or parallel space for inserting the closer or closing plank. This plank is prepared so as just to enter by force, it is then rubbed on the edges with soft soap, and is, by main force, and heavy mallets, driven flush with the other plank. The sheeting deals under the ends of the plank, and in the joints of the wedging crib, are then wedged tight, in the manner before mentioned. The main cribs *g g*, are then to be placed as counterforts, for the security and strengthening of the tubbing. These cribs are made in the manner before mentioned; they are about eight or nine inches in the bed, seven inches thick, and are placed at distances from each other, proportioned to the column of water to be resisted. At great depths they are laid close together, and the distance from each other increases as the pressure decreases, care being taken to have always a decided excess of strength, and made to bear equally against the tub deals, by means of wedging at the joints. The first main crib is laid close to the foot of the tub deals, and resting on the wedging crib. During this operation, the growth of water at the back of the tubbing is allowed to flow freely through a plug hole at the foot of the tubbing, until the whole operation is completed. The upper ends of the first set of tub planks are then cut square, and level all around. The second spiking crib *l*, is then fixed, and another set of tubbing deals put around as the former, having sheeting deal inserted betwixt the ends of the two sets at *f*. When this is wedged, the cribs *h h* are placed in the manner before described. According to this plan, tubbing may be carried upwards to any height, until the water rising at the back of it would discharge itself into the natural reservoir above the rock head, as is frequently done; but if a tubbing of a few fathoms is to be formed in a recess at a considerable depth from the rock head, then a wedging crib must be placed at the top of the recess, and firmly back-wedged, as at the lower wedging crib *d*. When this kind of tubbing is completed, the plug hole is filled up, and the water quickly rises and produces its full pressure. Although, from the nature of the operation described, it might be supposed that nothing could shrink even in the least degree, yet, as the pressure accumulates, the wood and the joints are heard very distinctly creaking by the excessive pressure. From this it is evident that no form but that of a circle could resist such a weight. After the full pressure is obtained, it frequently happens that veins of water, not thicker than a fine hair, will be found springing from the sides of the tubbing; these generally take up in a few days by the swelling of the wood. When all is secured, sheathing deals, inch and quarter thick, are nailed to the cribs all around the pit, not only to preserve the cribs from injury, but to make a smooth wall for the ascending and descending baskets with coals. These sheathing deals are put on in regular perpendicular courses, and the but-ends meet flush on one of the cribs.

The solid cribbing, executed with oak cribs only, and no tubbing deals, is a more complete piece of work than the former. If the pressure is great, they are formed three to four feet long, ten inches in the bed, and seven or eight inches deep, of the best oak, as before described. The first crib is laid down, and back wedged, in the same manner as the wedging crib in the plank tubbing, with this difference, that it has been found, that when the wedging was made in lines parallel to the sweep of the cribs, the immense pressure had a tendency to press forward the lower part of the crib; and it has been found from experience, that, if the wedging is done in a diagonal manner, it is much superior, and quite effectual. After the back wedging is completed, the next tier of cribs is laid down in precise position, having sheeting deal along the bed, and at each end joint, the perpendicular joints are overlapped in each set by the position of the next segments alternately, so that the face of the cribs, with the jointings of sheeting deals, has the appearance of ashler work. A wedging crib is fixed in the upper tier, if next the top of the recess, and the back wedging completed, as before directed. Each crib is set true to the radius of the pit, and the back of it filled up with pieces of wood betwixt it and the rock. When the whole space proposed to be cribbed is filled up, then the wedging of the joints commences while the water flows by a plug hole at the bottom. All the horizontal and perpendicular joints are gone over completely with one set of wedges; and, in the same way, a second and a third set of wedging is done, till wedges can be no longer driven. The face of the wedgings is then made smooth, the plug hole filled up, and the full pressure sustained. In this kind of work, innumerable fine veins or filaments of water issue from the wedgings, the water being forced through the pores of the wood. If these do not take up, additional wedging must be attempted, till not a particle of water can be seen issuing. In this piece of work, much ingenuity is displayed, and it reflects much credit upon the inventor.

The third mode of tubbing is by means of iron cylinders cast into segments. These are different from the drop or sinking cylenders, because they are placed piece after piece in the circular recess of the pit cut out for them. The flange for the wedging joint is sometimes towards the centre of the pit, but the improved method is, to turn the flange inwards. In the latest improvements of this plan, executed by Mr. Buddle, where there was a pressure of several hundred feet, the segments were six feet long, and two feet deep, an inch thick, counterforted with raised work on the back; the lip of the flange was strong, and supported by brackets. These iron segments of a cylinder are set true to the radius of the pit; and every horizontal and perpendicular joint has sheeting deal in it. A wedging crib is fixed at the bottom, and the segments are carried regularly up, having the joints like ashler work. This kind of tubbing can be carried to any height, until the water finds an outlet at the surface, or strata containing water can be tubbed off, as by the other kinds of tubbing before described. A pit completed in this manner presents a smooth shaft wall of iron, the flanges being towards the outside of the cylinders. In this work no screwed bolts are used for joining the segments together. In a pit in the Newcastle district, 70 fathoms have been executed in this manner, under Mr. Buddle's directions.

When a thin bed or parting betwixt two of the strata which are impervious to water, produces much water, or when the cutters or fissures in the strata do so, this water can be completely prevented from flowing into the pit by wedging, for which there is a particular method. In place of attempting directly to wedge the fissures, as was the former unsuccessful practice, the fissure is cut open with chissels, and made about two inches wide and seven inches deep, as represented Fig. 16. Plate CCCXC.; the lips are rounded off about an inch and half; pieces of clean deal are then driven in, the face of which comes no farther than the contour of the lips; the whole is then firmly wedged, till all the water is stopped back. By placing the wedging back from the face, the rock is prevented from bursting during the operation, which always happened in the former process.

In sinking engine pits, besides contending with the water, ventilation has to be attended to, on account of the pernicious airs or gases found in the strata, and which at times come off in great quantities. These gases are carbonic acid or fixed air, and carburetted hydrogen or inflammable air. The first of these gases being heavier than the atmospheric air, sinks to the bottom of the pit, and filling it up like water, displaces the common air, until it flows over the mouth of the pit. This air instantly extinguishes flame, and destroys animal life. The other gas, being lighter than air, instantly ascends the pit, mixed with common air. If this gas is much diluted with the common air, the workmen suffer no inconveniency from it; but if pure and unmixed, it destroys animal life, or if mixed with certain proportions of common air, it suddenly explodes and burns the workmen. These gases will be particularly noticed when the ventilation of mines is treated of.

In ordinary cases, while pits are sinking, the brattice walls produce a circulation, by the air descending upon one side and ascending by the other. If this does not take place, the circulation must be produced by fire rarefying the air.

The most approved method is, to cover the engine-pit area of the shaft with deals, having apertures for the pump spears and tackling to pass through, with hatch-doors for the men going up and down; near the top of the pit, and immediately under this scaffolding, a tube of brick, at least three feet square, is carried in a horizontal direction, and connected with a furnace having a high chimney with double doors, where the person enters to throw coals on the fire, as represented Fig. 3. Plate

CCCXCI. where *a a* are the double doors, *b* the mouth of the horizontal tube from the pit, *c* the furnace, *d* the ash pit, *e* the furnace building 8 feet high, arched with brick, *f* the chimney, which is from 50 to 100 feet high, according to the draught required, from 8 to 10 feet square at bottom, and tapering upwards to three or four feet, inside measure. The chimney-wall needs not exceed nine inches in thickness, if built of brick, after passing the extreme heat of the furnace, which is about 12 feet high, where there is a lining of fire brick; furnaces of smaller dimensions may be sufficient, in cases where they are only to be used while the pit is sinking; but those of large dimensions are suitable, not only for ventilating the pit, but the workings of the colliery afterwards. In some cases the horizontal tube is connected with the chimney of the engine furnace, with good effect, for the operation of sinking.

Another process is, that in place of covering the engine-pit area where the pumps are, as before described, to connect with the horizontal tube, deal boxes, having an internal area of from two to four feet. These are carried down the pit to within a few yards of the bottom, and produce a circulation of air, by being connected with a furnace at top; for as the air ascends through these pipes by entering at the lower part, the fresh air descends to supply its place. A temporary expedient is used in pits of a very moderate depth, by means of air boxes carried from the bottom of the pit to 12 feet above the surface, upon the top of which a hopper-shaped funnel is placed in a horizontal direction, which being turned with its aperture to the wind, sends a supply of fresh air down the pit. This plan is of no use in deep pits, or where the gases are very abundant. If a great quantity of gas issues from one place in the pit, it is found expedient sometimes to confine it in a tube, and conduct it to the top of the pit, where it dissipates into the air.

In those pits where it is proposed to draw a great quantity of coals, and with very considerable velocity, it is the practice to widen them at the place where the ascending and descending baskets of coal pass one another, which is termed the meetings. If there are two or three beds of coal in the pit, there will of course be different places for the meetings, as they are placed at half-way betwixt the mouth of the pit, and the coal which is working. The common practice is to make the pit 32 inches wider in the middle, that is, 16 inches wider on each side. It is evident that these cannot be made when there is tubbing in the way; and if there are many beds of coal to work in the same pit, it is better to make the pit of sufficient width from top to bottom.

These stones and rubbish produced in sinking are drawn up with horse-gins, when the pit is not deep; but in all pits of any considerable depth, the rotatory steam engine is used, and the workmen have now more confidence (as to their personal safety,) in these machines, than in the horse-gins.

The great collieries of Newcastle are frequently wrought by one shaft, divided in the manner before mentioned, which serves as an engine-pit and coal-pits, and by these the whole ventilation is carried on to an extent altogether astonishing. This system is followed on account of the immense expense which requires to be laid out upon a pit of this kind, an expense amounting in some cases from 40,000*l.* to 80,000*l.*, including the machinery. In general, however, the collieries of Great Britain are wrought by means of an engine-pit, and a series of pits, sunk at regular distances, suitable to the system of the colliery. The expense of these pits being comparatively very little, they are of various shapes, as before mentioned. When circular or octagon, they are about eight feet in diameter; when rectangular, they are eleven feet long by five feet broad. The long elliptical pits are eleven feet long by seven feet wide.

Common pits are in general easily sunk after the rock head is found, and the cover secured, particularly when the growth of water is such that no tubbing is required. The process followed is, to drive a mine to the place where the pit is intended to be, and having fixed the spot above ground from a survey made, the instant the pit is sunk to the rock head, a bore is put down to the mine, by which all the water descends, which aids the ventilation of the pit. In all rectangular pits, a small counterfort or bracket of rock is left at each corner, termed a pane, which strengthens the sides of the pit, and renders the sinking or walling of the pits easier. When the alluvial cover is secured by masonry of ruble work in square pits, it is the practice to throw arches of ashler stone in a vertical direction at every three or four fathoms distance. These strengthen the sides against the lateral pressure.

In the course of sinking, if any very soft strata are found, which have not consistency to form a firm shaft wall, a recess is cut out betwixt the firm strata upon the lower and upper side of the soft strata, and walls of masonry substituted, either of brick or of stone; and if beds of greenstone occur, or any very hard rock which will not wall smooth, but which, in blowing with gunpowder, leave large angular projections, such strata require to be walled down an extra width, in order to admit of masonry to form smooth sides. In all cases great attention is necessary to have the shaft walls as smooth as possible, that is, free from all projections and hollows, in order that when coals are drawn up with velocity, the basket or hutch may pass in a line as truly perpendicular as possible, otherways, if they touch, they are thrown first to the one side and then to the other, and continue a destructive oscillation, both in the ascent and descent, and do much injury to the coals, baskets, and pit. Where hutches are used made of deal, the injury thus produced is uncommonly great. When the workmen ride the shaft in going and returning to their work, the greatest attention must be paid, in order to have the shaft walls not only very smooth, but all the friable strata secured, because in deep shafts a very small bit of stone falling from a great height upon the head of a man proves fatal. In some shafts, when the strata are chiefly of the various kinds of clay and argillaceous schistus, they are cased from top to bottom with deals neatly jointed, and nailed to cribs or buntons fixed to the shaft walls; for the same cause some pits are built with brick or ashler from the bottom to the top.

The various processes pursued in working coal, and bringing it to market, have now to be detailed.

Coal, as one of the various strata of a coal-field, lies in a conforming situation with the other strata, like the leaves of a book; the stratum which rests immediately on it is named the roof, and the stratum upon which the coal rests is named the pavement, and in some districts, the thill. The terms roof and pavement are very appropriate, as the one is the roof or ceiling to the miner immediately above his head, and the other is that on which he walks. It is very remarkable in the natural history of coal, that the stratum upon which coals generally rest, is an argil or fire clay of various hardness, from the tenth of an inch to many feet in thickness. When coals rest directly on any other pavement, some trouble or dislocation of the strata is generally the cause.

A stratum bed, or seam of coal, is not in its texture one uniform solid mass, nor is it always of a homogeneous quality. Like the other accompanying strata, it is divided and intersected by what are named partings, backs, cutters, reeds, or ends. There are two chief partings in a coal, the one at the pavement, the other at the roof; these partings are the lines of separation betwixt any stratum and the adjoining one; sometimes it is only a fine line running horizontally, and scarcely visible, in other cases it is very distinct, and composed of either a dry powdery matter, or of clay, of about a twelfth or an eighth of an inch in thickness. Besides these chief partings at the roof and pavement, there are subordinate partings found in the bed of coal parallel to these, and sometimes very numerous; these vary in thickness from a line scarcely visible, to a parting of even more than half an inch. These partings in coal are generally composed of a glimmering fibrous substance, named mineral carbon, which is soft, and when touched blackens the hands very much. It is to be remarked, that this substance, though soft, is never found in the backs or cutters of the coal. These partings, backs, or cutters, are delineated in Fig. 4. Plate CCCXCI. where A, B, C, D; E, F, G, D represent a portion of a bed of coal, the parallelogram ABDC the parting at the roof, and EFG the parting at the pavement; *a b*, *b c*, *d e*, and *e f*, the subordinate or intermediate partings; *g h*, *i*, *k l m*, the backs; *o p*, *p q*, *r s*, *s t*, *u v*, and *v n* the cutters; from this it is evident that a bed of coal, according to the number of these natural divisions, is divided and subdivided into various sized solid figures, of a cubic or rhomboidal shape, according to the rectangular or oblique direction of the divisions to one another; the partings are always parallel to the roof and pavement, excepting where there are troubles in the strata, and the backs cross the partings at right angles to their planes. But though cutters are found sometimes running at right angles to the line of the backs, they more frequently cross them obliquely; so that in the one case the figures formed are rectangular solids, in the other case they are solids of a rhomboidal form.

Besides these common divisions in the coal, there are occasionally found accidental divisions in various directions, but generally in a line somewhat in the direction of the backs, and passing like them from roof to pavement; these are termed leips or glazed backs, on account of their glossy surfaces, which have no tenacity as to each other, and are the occasion of misfortunes, some of them fatal to the workmen. When the backs, cutters and partings are good, as the miners term them, they greatly aid their labour in working thick beds of coal, particularly where the coal is strong and works large; they are of less importance in the soft caking coals, such as are found in the north of England. In strong coals, where the divisions are good, they are termed back and end coals, and they break out into pieces of quadrangular form, with smooth planes, and produce comparatively little waste coal, culm, or dross, in the open burning coals; but where the partings, backs and cutters are bad, the coal is greatly injured in the working, and much culm is produced, which is of little or no value. When the partings are bad, the coal is said by the miner to have neither roof nor pavement; and when the cutters are irregular, the coal breaks in that direction very much serrated, or teethy in the miner's language.

Besides these chief and regular divisions, there are innumerable cracks and fissures crossing one another, so that when the coals are broken with force, the fragments are of a cubic form, particularly in open burning bright coal, named on that account cubical coal, in place of rough coal or cheary coal, as formerly. On the other hand, the coals named splint coals (slate coals) have few of these cracks, but have a slatey fracture parallel to the roof and pavement of the coal.

With regard to the tons of coal of 20 cwt. each, contained in an English or Scotch acre, the weight of a cubic foot of coal varies from 75 to 80 pounds avoirdupois, which gives a range in the cubic yard from 18 cwt. to very near a ton. In practice it is common to reckon the cubic yard 18 cwt. which is exactly half a hundred weight for each inch in height of the square yard; upon this principle a coal three feet four inches in thickness contains a ton in every square yard of the area, hence an English and Scotch acre of this thickness contain the following weight of coals:

	Tons.
An English acre -	4840
A Scotch acre - -	6084

From the above quantities, there falls to be deducted the proportion of coal to be left in pillars, besides an allowance for waste, before the exact produce per acre can be ascertained; from the above data, the quantity of coal of any thickness contained in an acre, may be very easily calculated, but the calculations must be corrected according to the kind of coal and peculiarities connected with it.

When the engine-pit is sunk, and the lodgment formed, the next thing to be done in collieries of a moderate depth, and where a number of pits are to be sunk for drawing the coals, is to run a mine in the coal to the rise of the strata, or a cropping from the engine-pit to the second pit. Where inflammable air abounds, the primary point of attention is the ventilation for the safety of the workmen; but as this is an intricate and important point in the mining operations, the opening up of a colliery will be described, where only carbonic acid or fixed air is found; where there is little danger, and where the means of ventilation are of the simplest kind. In many mining districts, the second pit sunk to the rise of the engine-pit, is named the bye-pit, that is, the pit farther up. The mine which is carried from the engine-pit to the second pit, may be 6 or 8 feet in width, and is either carried in a line directly to the pit-bottom, or it is carried at right angles to the backs or web of of the coal, until it is on a line with the pit where a mine is set off, upon one side to the pit bottom. This mine is carried parallel to the backs, or as nearly so as possible, till the pit is gained. Fig. 5. Plate CCCXCI. represents this operation; A the engine-pit, B the bye-pit or second pit, AC the mine run at right angles to the backs, CB the mine set off to the left hand parallel to the backs. Mines which are carried in this direction at right angles to the backs, or parallel to them, are the best, because the pillars which are formed next them are in equal areas, stronger than pillars formed by the sides of mines, which are driven oblique to the backs and cutters, particularly if they are of an open kind. The next operation is to drive the dip-head, or main-levels from the engine-pit bottom, or from the dip hand of the backset immediately adjoining the engine-pit bottom; for this work the best colliers are always chosen, as the object is to drive the mine in a true level direction, and that independently of all sinkings or risings of the pavement. This mine is generally not more than six feet wide in coals of ordinary thickness; the rule is, to have upon the dip-side of the mine a small quantity of water, like that of a gutter, so that it shall always be about four or six inches deep at the forehead upon the dip-wall. In coals which have a great dip, the water may be eight inches deep; and in very flat coals from two to three inches will be sufficient; for this reason, that if the dip is 1 in 3, then the water which is 8 inches deep will be in breadth 24 inches, whereas in a coal dipping 1 in 12, the water 3 inches deep will be in breadth 3 feet. When the level is driven correctly with the specified depth of water, it is said to have dead water at the forehead; the miner, therefore, in this operation pays no regard to the backs or cutters of the coal, but is guided in his line of direction entirely by the water, which he must alone attend to, and that without regard to slips or dislocations of the strata which may throw the coal up or down. In Fig. 5. the coal-field is a portion of a bason, from which it is evident from what was before stated, that if the shape is uniform and unbroken, and if any point is assumed a dipping from the crop as D, the level lines from that point will be parallel to the line of crop, as DE, DF, and the levels from any point whatever a dipping, will be also parallel to these; therefore, if the coal-field is an entire elliptical bason, the dip-head levels carried from any point would be elliptical, and parallel to the crop. If, however, and which is more commonly the case, the coal-field is only a portion of a bason formed by a great dislocation or slip of the strata, as represented in Fig. 6, where *a a a* is the crop, and AB a slip of great magnitude, forming another coal-field on the side C, then the crop not only meets the cover, but is cut off by the slip at A and at B. If, therefore, any point is assumed, as D, for an engine-pit, the levels from it will proceed in a line parallel to the crop, as D *d*, D *c*, and the level on both sides of the engine-pit will be cut off also by the slip AB. In this Figure, the shaded part is the breadth or breast of coal-field won by the engine-pit D: what is not shaded is termed the under-dip coal, and can only be wrought by one or more new winnings towards the dip, according to circumstances. Had the engine-pit been placed at the point E, close to the slip AB, it would have drained or won the whole of that coal-field, and no level mines could be driven, but a common mine run from E to B, and from E to A; which mines, in place of being level, would have a moderate rise from E to B and from E to A, where they would terminate with the coal where the crop meets the cover. In such a case, these mines are not carried close to the slip, but a few yards to the rise of it, in order to leave a barrier or chain wall of coal to support the superincumbent strata, which are ready to give way at the fissure of the slip where all the strata are disjoined and dislocated.

The third general case as to dip-head levels is, when the coal-field is a portion of an inverted bason, as Fig. 7. where *a a a* is the crop of a coal, and B any point assumed for an engine-pit to make a winning. In this case, the dip-head levels will proceed from B to *c* and from B to *b*, parallel to the crop, till they are cut off either by a slip AC, or reach a trough, where the coal rises in different directions. In extensive coal-fields, which are in general lying fair, if a conical swelling of the pavement is found of some considerable extent in the line of the dip-head level, the level will then, in keeping a true level line, assume the form of a horse-shoe, and, after passing the swell, will proceed in its regular course as before.

Having thus stated the general principles upon which dip-head levels are carried in the regular system of coal-mining, it will be proper to exemplify the effects of moderate swells and hollows of the pavement, as the levels proceed onward from the engine-pit bottom, as in Fig. 5. When a hollow occurs, the level is thrown to the rise, and, as the hollow decreases, the level sweeps again to the dip; whereas, when a swell occurs, the level is thrown a dipping, and, as the swell diminishes, the level gradually again turns to the rise. In these cases, a sudden turn, or a sharp angle, is never made in the mine walls, but the course is pursued by inflections as moderate as the case will admit of. From what has been stated, it is evident that if the miner holds to the dip hand more than the true level course will allow, he will make what is termed a drowned level; and if he keeps too much to the rise, he will produce what is termed lost level; and, if the lost level is not recovered, the breadth of the breast of coal-field won will be made narrower, which is a loss, as the expense of recovering lost level is often very great. Fig. 8 represents a portion of a dip-head level, where these errors have been committed. AB is the dip-head level in its true course, carrying dead water at the fore-head B, from the engine-pit A. *a* is the fore-head of a piece of drowned level, which must be abandoned, and left to fill with water; the proper level is regained by resuming the work at *b*, where the error commenced; *c* is the fore-head of a piece of lost level commencing at *d*. By this error, the triangle of coal B *d*, *d c*, *c* B, is lost in the winning; and to correct this error, the true level must be begun at the point *d*, and carried dead level to the fore-head B. Drowned levels can never be of great extent, as the water very soon incommodes the workman, and forces him to return. But lost levels sometimes go forward progressively for years, when at last the breast of coal-field becoming evidently much narrower, the true level must often of necessity be regained, which requires years of labour, and very great expense, all of which might have been saved by correct mining. This, therefore, shows, that the driving of dip head levels correctly, particularly in deep winnings, is a point of the very first importance. They ought to be kept clear of all stones, rubbish, and sediment, as these tend to cause loss of level, by damming the water, and throwing a greater depth of it at the fore-head, than would be if the level was clear and patent. Wherever the roof is bad, it ought to be firmly secured either by carpentry, or by masonry, which is better. These being the modes of driving dip-head levels in the different kinds of fair-lying coal-fields, the plans to be pursued when dikes, slips, and dislocations occur, have next to be pointed out. Fig. 9 represents a coal-field won by the engine-pit A. *a a* is the crop, and the double lines proceeding east and west from the engine-pit are the dip-head levels. B and C are two dikes traversing the coal-field in a crop and dip direction, but which do not throw the coal either up or down. When, therefore, the dip-head level is obstructed by the dike

B, and found to be of that kind which neither throws the strata up or down, then the level is carried through, as represented in the Figure, when the coal will be found on the other side at *d*. Upon the level proceeding to *e* another dike is found, throwing down the coal; but as the extent of this downthrow is not known, a mine is carried level course, not only through the dike, but several fathoms farther forward, as to *f*, where a bore is put down, and the downcast proved to be ten fathoms. This being the case, and if the coal dips 1 in 8, then 8 ×10 is 80, which shows that if a level mine is run in the strata in a direction parallel to the dike, or nearly so, a cropping as *g h*, the coal will be found at *h*, and the distance will be 80 fathoms as above calculated, provided the coal keeps the same dip and rise as formerly. The dip-head level then proceeds from *h* eastward in manner as before directed. It must, however, be observed, that though the stone mine and effect of the downcast have thrown the dip-head level 80 fathoms a cropping, the breast of coal from the dip-head to the crop is not narrowed, as the coal upon the east side of the dike will be found to go southward, at least as much farther than the crop upon the west side of the dike, as represented in the Figure.

In proceeding with the dip-head level westward from the engine-pit A, the slip *k* is found throwing down the coal and other strata. A mine is carried forward to *l*, and a bore put down where the slip is ascertained to have thrown down the coal 5 fathoms, hence 5×8 gives 40. Therefore, if a mine is carried dead level a cropping from *m*, the coal will be found at *n*, the distance from *m* to *n* being 40 fathoms, providing the dip of the strata continues the same; and, in this case, the crop of the coal extends 40 fathoms farther a cropping, as represented in the Figure. The coal having been found at *n*, the dip-head level proceeds from *n* to *o*, where an upthrow slip is found, but the extent of the upthrow unknown. Sometimes the coal is searched for, by mining upwards for a few yards; but the common practice, is to run forward a mine a few yards, and bore upwards, as at *p*, where the coal is found to be 10 fathoms up; then 10 ×8 gives 80. If, therefore, a stone mine is carried dead level through the strata a dipping, the coal will be found at *r*, at the distance of 80 fathoms from *q*, supposing the dip to be the same as formerly. But although the dip-head level is carried a dipping 80 fathoms, no additional breadth is gained to the breast of coal, as the crop is thrown an equal extent back, as in the Figure. From *r* the dip-head level proceeds to *s*, where a downthrow slip is found to be 4 fathoms; 4×8 gives 32. A mine is therefore set off a cropping from *t*, but in place of running 32 fathoms ere the coal is intersected, it is found at the distance of 20 fathoms at *u*, which shows that the coal is dipping 1 in 5, in place of 1 in 8, as formerly. This slip runs out, or comes to nothing, as it is termed, in the crop, consequently narrows the breast of coal 20 fathoms. Had the dip been rendered less, suppose 1 in 20, then it would have required a mine of 80 fathoms in place of 20 fathoms to intersect the coal, and it is probable that the breast of coal would have been broader, but this depends upon the situation of the slip towards the crop. When the dip-head level, as at *v*, meets with a slip throwing down the coal; and if upon cutting forward the coal is troubled, the mine must be continued still forward, till the strata are found lying regular. In the example given, there are five slips or dislocations very near one another, throwing the strata at one time up, and at another down, but only a few feet in extent. If, upon reaching the point *w*, the coal is not found by a bore either up or down, and if no clear view can be formed of the coal-field in that direction, it may be necessary to explore the field by a series of bores put down from the surface. In the Figure referred to, examples are given of the effects produced upon the line of direction of the dip-head level by dikes and slips, and the modes practised in passing them; but as these slips and dislocations lie in every direction as to the dip and rise of the coal, there are of course very various modifications of the examples given, to enumerate which would be of little use, although the example given appears to be a coal-field much troubled, as it is termed. We have seen in practice coal-fields even with more numerous dislocations. On the other hand, we find coal-fields lying fair and regular to a very great extent.

If, in working the coal from dip to rise, slips or dislocations of the strata occur, they are passed over in several ways, according to the size of the slip.

When the slip is only a few feet down to the rise, the coal is regained at the face of the slip by an open cutting like a trench, named a hassan; but when it is several yards down, and not exceeding the depth of 25 feet, an inclined road or mine is made down the face of the slip, or at such an angle as may be most suitable for bringing up the coals; and in order to take away the water, a syphon is sometimes used in place of a pump, as the column of water to be raised is less than the pressure of the atmosphere; for although water will rise over a height of more than 25 feet by a syphon, it runs feebly, and will not discharge much water. The long end of the syphon is carried down the slope of the coal towards the engine-pit, where the discharging orifice is immersed in a trough of water, each end is furnished with a stop-cock, and at the neck or highest part of the syphon, an upright pipe is attached, upon the top of which is a funnel, and a stop-cock below it. These syphons were formerly made of lead; but the mode of joining cast-metal pipes air-tight being so effectual, syphons are now made of that metal.

When a slip is of considerable magnitude, it can be levelled out by a cross-cut mine, begun sufficiently to the dip. These cross-cut mines are made of a size sufficient to allow the coals being brought down through them to the pit bottom. When the coals are very flat, and the running of cross-cut mines may not be judged expedient, the coal is regained, either by cutting a sloping mine, or by sinking a pit clear of the rise or slope of the slip, to the coal. Sometimes the water is drawn up in pumps connected with machinery at the top of the pit, or is drawn by machinery wrought by men, horses, or steam, by which means the coals are also drawn. Of these plans there are various modifications, according to the magnitude of the slip, and its particular direction as to the dip and rise of the coal. When the slip is of great magnitude, it is frequently judged expedient not to attempt to connect it with the established fitting, but to make a new fitting for the coals on the other side of the slip, the slip serving as a complete barrier betwixt the two coal-fields, which in many instances is an important matter to attend to, on account of the water. When the slip is up to the rise, which is not a common occurrence, the operation of connecting the coals on the other side of it with the main workings is very simple, as there is nothing to do but updrift a mine to the coal, and then open it out to a proper width for a pit. By this pit the water descends, and the coals are lowered down by a machine, with a rope-barrel regulated by a brake, by which the descending loaded corve draws up the empty one alternately. This mode of lowering coals to a lower level is very applicable in many cases.

As soon as the crop or rise mine is run to the second pit, in winning a colliery, and the dip-head levels extended from 30 to 80 fathoms on each side of the engine-pit bottom, the colliery is ready for working, or for producing an output of coal; but, before proceeding, an important point has to be settled, viz. the manner in which the mines are to be conducted, so as to insure, as far as possible, 1st, *The safety of the workmen;* 2dly, *The prosperity of the work;* and 3dly, *That a given area of the coal field be made to yield the greatest possible proportion of the coals contained in it.*

In the mining practice of Great Britain, there are four different systems of working coal mines, viz.

1st, Working with pillars and rooms termed post and stall, where the pillars are left of such proportion to the coal excavated, as is just sufficient to support the superincumbent strata.

2d, Working with post and stall, where the pillars are left of an extra size, and stronger than is judged to be requisite for supporting the strata, with the view of taking away a considerable proportion of each pillar, as soon as the regular working of post and stall is completed in the colliery.

3d, Working with post and stall, or with rooms or boards comparatively narrow, and very large pillars or rather walls of coal, whereby an uncommonly large proportion of coal is left, having in view, that as soon as the colliery is wrought to the extent of the coal-field in this manner, to work back towards the pits, taking away, if possible, every pillar completely, and allowing the whole superincumbent strata to crush, and follow the miners as they retreat.

4th, Working the long way, or the Shropshire method, which is to leave no pillars, but to take out all the coal progressively, as the work goes forward. In this method the superincumbent strata crush down, and creep very close to, and even over the heads of the workmen.

In practice the post and stall system is applied in the working of coals of every thickness. The Shropshire method, or long way, is more generally applied in the working of thin coals. When the thickness exceeds 6 or 7 feet, this mode of working has not yet been found practicable.

When a colliery is won in the manner as before described, the next important matter to be considered, is, By what plan of working the coal will that coal in particular, and the coal-field in general, produce the greatest quantity of vendable coals from a given area, having in view all local circumstances, and also the future as well as the immediate interest of the coal-field?

The local circumstances may be ranged under the following heads:

1st, That the lowest coal of the winning be wrought in such a manner as not to injure the working, or the value of the upper coals which may be in the coal-field; but if this evidently cannot be accomplished, the upper coals must be wrought first.

2d, The texture of the coal, as to hardness or softness, and whether the backs and cutters are numerous or not, open or close.

3d, The kind of pavement upon which the coal rests, whether it is soft or hard; and, if soft, whether it is only a few inches or several feet in thickness.

4th, The kind of roof, whether it is good or bad; that is, whether it is firm and strong, or very weak, and liable to fall down; also the kind of superincumbent strata, whether strong or tender.

5th, The kind of alluvial cover, whether of a dry nature, or composed of quicksands and much water upon the rock head.

6th, The situation of rivers or collections of water connected with the coal-field, particularly if these are near the crop of the coals.

7th, The situation of towns, villages, and mansion-houses upon the coal-field, whether they are likely to be injured by any mode in which the coal is proposed to be wrought,—having in view the thickness of the strata betwixt the surface and the coals to be wrought, also the thickness of the bed or beds of coal.

When coal-fields have been wrought in a district of country for a considerable period of time, the experience, gained by the miners directs them how to proceed in similar circumstances, and therefore, in mines opened up in new districts, it is difficult to lay down specific rules for the very various circumstances connected with a coal-field; and although general rules may be laid down, it may require years of experience, and the trial of many modes, ere the best system can be determined upon.

The following general rules are useful in determining the mode of working coal.

1st, If the coal, pavement, and roof are of ordinary hardness, the pillars and rooms may be proportioned to each other, corresponding to the depth of the superincumbent strata, providing all the coal proposed to be wrought is taken away by the first working, as in the first system; but if the pillars are to be winged afterwards, they must be left of an extra strength, as in the 2d system.

2d, If the pavement is soft, and the coal and roof strong, pillars of an extra size must be left, to prevent the pillars sinking into the pavement and producing a creep.

3d, If the coal is very soft, or has numerous open backs and cutters, the pillars must be left of an extra size, otherwise the pressure of the superincumbent strata will make the pillars fly or break off at the backs and cutters, the result of which would be a total destruction of the pillars, termed a crush or sit, in which the roof sinks to the pavement, and closes up the work.

4th, If the roof is very bad, and of a soft texture, pillars of an extra size are required, and the rooms or boards comparatively very narrow.

In short, keeping in view all the circumstanaes before mentioned, it may be stated generally, That when the coal, pavement, and roof are good, any of the systems before mentioned may be pursued in the working; but if they are soft, the plan is to work with rooms of a moderate width, and with pillars of great extra strength, by which the greater part of the coal may be got out, at the last of the work, when the miners retreat to the pit bottom, and there finish the workings of a pit.

When pillars are left haviog too small a base, though abundantly strong in themselves, but resting on a soft pavement, the sure consequence is, their sinking into the pavement by the weight of the superincumbent strata, which produces a creep over all the workings, and has the effect of shutting up the roads, destroying the air courses, and deranging the whole economy of the colliery operations below ground. Fig. 10. Plate CCCXCI. represents the effects of pillars sinking into the pavement, and producing a creep. Fig. 11. represents large pillars, and a room, with the roof stratum bending down before it falls at *a*.

With regard to the proportions of coal wrought, to the area left in pillars for support of the superincumbent strata, where all the coal intended to be wrought from a given area is taken at the first working, it varies from four-fifths to two-thirds; and in a general view these are about the proportions in the present practice pursued under the system, when the depth does not exceed 70 fathoms; but as the losing of a third of the whole area of coal is a great proportion, the superior mode of working, as stated in the third system, ought to be adopted.

The rule for calculating the proportion of coal wrought to the area left in pillars, is as follows: It is termed calculating the proportion wrought of a winning. Plate CCCXCI. Fig. 12. represents a small portion of the pillars, rooms, and thirlings, formed in a coal-field. *a a* are two rooms, *b* the pillars, *c* the thirlings. Suppose the rooms 12 feet in width, the thirlings the same width, and the pillars 12 feet on each side. Add the face of the pillar to the width of the room, $=24$, add also the end of the pillar to the width of the thirling, $=24$. then $24 \times 24 = 576$—then the area of the pillar, $12 \times 12 = 144$. And as 576, divided by 144, gives 4, the result is, that a fourth of the coal is left in pillars, and three-fourths wrought out. *d*, *e*, *f*, *g*, is one winning, and *g*, *e*, *k*, *h* another. From an inspection of the figure, the workings of a coal-field, if regular, resolve themselves into quadrangular areas, having the pillar situated in one of the angles.

As the backs in the coal do not generally lie at right angles to the dip and rise of the coal, but rather oblique to that line, the rooms or boards are begun or broken off at the dip-head level, so that the backs of the coal cross the sides of the boards at right angles. This by some is termed working right upon the plane of the coal, others term it right upon the web; but if cutters are more distinct and open than the backs, then that direction is termed the plane, and the boards are said to be wrought upon the end plane, or simply on the end, or in a level course direction.

In forming the pillars, and carrying forward the boards with regularity, particularly where the backs and cutters are very distinct and numerous, it is of importance to work the rooms at right angles to the backs, and the thirlings in the direction of the cutters, however oblique these may be to the backs, as by this plan the rooms are conducted with the greatest regularity with regard to each other, kept equidistant, and the pillars of a given area are the strongest when formed by this mode of working.

At the same time, it must be understood, that it seldom happens that a back or a cutter is found exactly at the place where a pillar is formed; but that is of no consequence, as the shearing or cutting made by the miner ought to be in a line parallel to the backs and cutters. This precise system is particularly necessary, where pillars are formed upon the calculation of just supporting the superincumbent strata, or when they are made a little stronger, to be winged afterwards. This preciseness is dipensed with where immense pillars or walls of coal are left in the first working, with the view of taking out the whole afterwards. At the same time, even in this system, the working of the rooms with their sides parallel to the cutters, is the best method of keeping all the rooms at equal distances from each other, so that betwixt each there may be a regular and uniform thickness of pillar. If the pillars are formed without attending to the above plan, their sides will intersect through the backs and cutters obliquely; and when the weight begins to bear upon them, and are winded by the air passing through the waste, large wedge-shaped pieces of coal fall off.

It frequently happens that the dip-head level, in its course, intersects the cutters at a very oblique angle. In this case, when rooms and pillars are set off, the face of the pillar, and width of the room, must be measured off an extra breadth in proportion to the obliquity, as in Fig. 15. Plate CCCXCI. Without attention to this, much confusion and irregular work is produced; on which account, the pillars are always formed much larger than in the common workings; besides, it is a general rule to make the first set of pillars next the dip-head level, even where there is no obliquity, much stronger, in order to preserve the dip-head level from being injured by any accidental crush of the strata.

Having thus described the manner of arranging the rooms and pillars, the various systems of working coal have now to be explained.

Fig. 13 shows one of the simplest modes of working coal. A is the engine pit, B the bye-pit, or No. 2 pit, CD the dip-head levels, always carried in advance of the rooms, E is the rise or crop mine, also carried in advance. These mines not only open out the work for the miners in the bed of coal, but, by being in advance, give plenty of time for any operation which may be required, if these mines are obstructed by dikes or hitches. In this example the rooms or boards are wrought from the dip to the crop; the leading rooms, or those most in advance, are those on each side of the crop mine E: all the other rooms follow in succession, as represented in the figure; consequently, as the rooms advance to the crop, additional rooms are begun at the dip-head level, towards C and D. If the coal is found to work better in a level course direction, then the leading rooms are next the dip-head level, and the other rooms follow in succession. In this manner, the rooms are carried a cropping in the one case, till the coal is cropped out, or is no longer workable; and, in the other case they are extended as far as the extremity of the dip-head level, which is cut off either by a dike or slip, or by the boundary of the coal-field. As to additional pits, these are placed at such distances from each other, as will best suit the economy pursued in working. When the winning is under 60 fathoms in depth, and the sinking of pits is of little expence, they are numerous; but when they are deep, and attended with very great expense, one shaft divided into two or more pits can be made to work out a very extensive coal-field.

In very deep winnings of from 80 to 200 fathoms in depth, the first workings are carried forward with rooms, pillars, and thirlings, but under a very different arrangement, both on account of the great depth of the superincumbent strata, the enormous expense laid out in sinking a pit, and the order, regularity, and strictness of discipline indispensably requisite for ventilating the mines, preserving the lives of the workmen, and prosperity of the whole establishment. In these deep winnings, the same general system is followed, as stated regarding dip-head levels, and crop mines, excepting those peculiarities connected with the ventilation, which will be treated of separately. In the early practice of working deep collieries, the system was, to work with pillars considerably stronger than was conceived necessary for supporting the strata, in order that when the workings were carried on to the full extent proposed, the workmen might begin with the pillars at the greatest distance from the pit bottom, and either work a certain proportion from each, securing themselves from the falls in the roof by prop-wood, or they sometimes wrought the heart out of a pillar, either in the one direction or the other, and sometimes in both directions. Though the size of the pillars and general arrangement of the work, were laid out with the view of taking out a great proportion of the pillars ultimately, yet it frequently happened, that, before the workings were extended to half the proposed extent, some part of the work gave way, and produced a crush; but the most common misfortune was the pillars sinking into the pavement, and deranging the whole economy of the work. When either a crush or creep commences under such a depth of strata, it is almost impossible to stop its progress; the pillars thus sunk into the pavemant are lost. But if a crush or creep did not take place during the working of the colliery, and the working of the pillars commenced, a crush or creep is expected very soon to come upon the weakened pillars. In this case it frequently has happened that the pillars, in their entire state, had not strength to keep back the crush, and therefore it overran the pillars, making the workmen abandon the work and escape for their lives. In this manner, also, much coal was lost. If the crush or creep was not so violent as this, it frequently was resisted for some time by the strength of the pillars, but it was impracticable to resume the work close to the creep; and therefore a great breadth and stretch of pillars had to be left as a barrier betwixt the crush and the next set of pillars which was to be wrought. In this manner were collieries carried on, and an immense proportion of the coal lost for ever. This loss amounted in many cases to no less than a third, and, in some instances, even to a half of the whole area of the coal-field. This great loss of coal was not only making an uncommon sacrifice of mineral property to the mine-owner, and to all concerned in the working of it, but the loss was great in a national point of view, as the coal thus left under ground was lost to all generations. An improvement, therefore, in the system of working deep mines became a great desideratum, and many plans were brought forward by mining engineers of the greatest experience.

Besides the loss of coal by the system before mentioned, there was another great evil which required also to be corrected. In carrying on the workings of an extensive colliery or coal-field of one or more hundred acres, the whole area or extent of the coal-field was one continued range of rooms and pillars, communicating with each other, without any divisions or barriers of coal left across the workings, excepting when formed to counteract a crush or creep already begun, or to strengthen the waste adjoining a slip or dislocation of the strata; the consequence of this system was, that if a crush or creep began when the workings were much extended, they overran very frequently the whole of the pillars, and were only resisted by the whole coal at the wall faces, so that the ventilation was entirely deranged, the roads leading from the wall faces to the pit-bottom shut up and rendered useless, and the recovery of the colliery by means of new air courses, new roads, and opening up of the wall faces or rooms, attended with uncommon expense and danger. Even when the pillars stood well, this system had other very great inconveniences attending it; for if water broke out in any particular spot of the colliery, it was altogether impossible to prevent it from proceeding to the engine pit, and if the ventilation was obstructed, no idea could be formed where the cause was likely to be found, there being instances of no less than thirty miles of air courses in one colliery; and if from such an obstruction an explosion of the gas took place while many workmen were employed along the extended wall faces, it was altogether impossible to form any judgment where the misfortune had taken place, and consequently the viewers or managers, with their assistants, could not direct their steps to that point where they were most likely to relieve the workmen who had survived the shock of the desolating explosion.

To the mining engineers of the northern counties of England, known in that quarter by the name of *Viewers*—the world is indebted for many great improvements which have been made in the most difficult and dangerout points of coal mining. They are a class of men who, to a knowledge of physical science, add patient perserverance, resolute determination, contempt of danger, and unwearied application; nor are these qualities called only occasionally into action, they are required every day of their lives, while they direct the operations of extensive and deep mines, where inflammable air abounds.

All the expedients proposed having failed to correct the evils attending the working of deep and extensive mines, where inflammable air abounded, and as one of the great objects was to raise as much coal as possible from a given area, in place of losing a third or a half, as before-mentioned, a system altogether new has been invented and brought forward, by Mr. John Buddle, of Wallsend Colliery, Newcastle. This system, the result of the greatest experience, and of much study, has, under his immediate direction, been put in practice with a success equal to his most sanguine hopes, and is now adopting by the mining engineers in the north of England.

This system of Mr. Buddle's is named pannel working, because, in place of the colliery, or winning of a coal-field, being carried on in one extended area of rooms and pillars, it is divided into quadrangular pannels, each pannel containing an area of from eight to twelve acres; and around each pannel is left a solid wall of coal of from 40 to 50 yards in thickness; through the pannel walls, roads and air courses are cut, in order to work the coal contained within the walls. In this way, all the pannels are connected together as to roads and ventilation with the shafts or pit; and for the more immediately distinguishing any particular part of the colliery, each district or pannel is named after places or countries, such as London, Edinburgh, Dublin, &c.; so that any circumstance regarding the operation of the colliery, accidents as to falls and crushes, ventilation, and, above all, the safety of the workmen, can be referred to a precise spot, under defined limits, viz. within the walls of any particular pannel. Fig. 1. Plate CCCXCII. represents a part of a colliery, laid off with four pannels, according to the improved method; and in order to render it as distinct as possible, the line of the boards is at right angles with the dip-head level, or level course of the coal. A, is the engine pit, divided into three pits, viz. an engine pit and two coal pits; one of the coal pits is the downcast, by which the atmospheric air descends to ventilate the works, and the other coal pit is the upcast shaft, at the bottom of which the furnace for rarifying the air is placed. BC is the dip-head level, AE the rise or crop mine, K the pannel walls, FG are two pannels completed as to the first work; D is a pannel, with the rooms *a a* in regular progress to the rise; H is a pannel fully wrought out, where all the coal is nearly got, the loss being in general not more than a tenth in place of a third, or a half under the old system. By this improved plan, the pillars of a pannel may be wrought at any time, as may best suit the economy of the work. In this system, the pillars are made very large, and the rooms or boards narrow—the pillars being in general 12 yards broad, and 24 yards long; the boards four yards wide, and the walls or thirlings cut through the pillars from one board to another, only five feet wide for the ventilation. In the figure, the rooms are carried from the dip to the crop, and the pannel walls act as barriers thrown round the area of the pannel, which prevents the crush of the superincumbent strata from overrunning the adjoining pannels. When the pillars of a pannel are to be wrought, a range of pillars, as at I, is first begun upon; and as the workmen cut away the farthest pillars, prop-wood is set up betwixt the pavement and the roof, in a perpendicular direction, within a few feet from one another, as represented by the dots, until an area of above 1000 square yards is cleared of pillars, having a thickness of strata, perhaps more than 130 fathoms, hanging clear and unsupported, excepting at the line of the surrounding pillars; this is termed working the goaff. It must however be remarked, regarding the prop-wood which is here used, and in many other places of the pit-workings, that it can have no effect in supporting the weight of the whole superincumbent strata, which is uncommonly great. The only use of prop-wood is to prevent the bed or stratum, which forms the roof immediately over the workmen's heads, from falling down and killing them; experience having shown, that before proceeding to take away another set of pillars, it is necessary to allow the last made goaff to fall. The workmen then proceed to draw the props, which is a most hazardous employment; they begin at the farthest props, and knock them down one after another, retreating always amongst the remaining props. During this operation, the roof-stratum begins to break by the sides of the pillars, and falls down in immense pieces. This does not intimidate the workmen, for they persevere drawing and retreating, until every prop is taking down; and if any props are so firmly fixed by the pressure of the roof that they will not drive down with the force of heavy mauls, they are cut through with axes, the workmen deeming it cowardly to leave a single prop in the goaff. When every prop is drawn, the workmen retreat betwixt the pillars for safety; the roof then falls in large tabular masses, and each superior stratum, in succession, bends down towards the middle of the goaff, and then breaks. The workmen then proceed to cut away the pillars next the sides of the goaff, setting prop-wood, drawing it, and retiring in the manner before described, until every pillar of the pannel is removed, excepting small parts of pillars which require to be left under dangerous stones, to secure the retreat of the workmen. While this operation is going forward, and the goaff extending, the superincumbent strata, having an enlarged area without support, break progressively farther up; and when strong beds of sandstone are breaking, the noise of the rending of the mass of rock is very loud, and the sound very different from any thing the ear has been accustomed to; at times it is loud and sharp, at other times very loud, but hollow and obtuse; this last kind of sound the workmen very emphatically term thudding.

It is the opinion of the most eminent of the Newcastle engineers, who have had the greatest experience, that when goaves are wrought under very deep cover, the rupture of the strata does not in general continue up to the surface, but that the upper part only bends down a little. As the pillars of the pannels are taken away, the pannel-walls are also wrought progressively backward to the pit-bottom, so that by this operation, only a very small proportion of the coal is lost. This is, as far as can be judged, the very best method of working such coals as those at Newcastle, taking into consideration their great depth from the surface, their comparative softness, and the great abundance of inflammable air. It is evident, that the larger the pillars and pannel walls are in the first working, the greater will be the security of the workmen, and the certainty of taking out in the second working the greatest proportion of coal. This system is applicable in many instances through the collieries in Great Britain; by it the saving of coal is uncommonly great, compared with any of the post and stall plans. Though we may view this wonderful operation as one which shows in a strong light the bold and determined spirit of man, even in the mechanical part of the operation, where the massive rocks are reft and torn to pieces over the head of the miner, a more difficult and delicate operation has to be attended to during the process, that is, in conducting atmospheric air to the workmen to counteract and carry off the excesive flow of hydrogen gas, which issues from every quarter ready to destroy them, as will be noticed when treating of ventilation; so that man may be considered in this case as contending with the elements of nature, which are every moment ready to overwhelm him. The consideration of these circumstances shows the importance and nature of that charge, which devolves upon a mining engineer in these deep and very dangerous collieries.

Under the fourth system of coal-mining, is that named the Shropshire method, long way, or long wall.

This system was first pursued in Shropshire, but the name of the person who had the merit of inventing it is not known; the plan must at first have been uncommonly hazardous, though now it is reckoned as safe, if not safer for the workmen, than the other system with rooms and pillars.

The object of the Shropshire system is to begin next the pit-bottom pillars, and at once to cut out every inch of coal progressively forward, and allow the whole superincumbent strata to crush behind and over the heads of the workmen. This system is confined chiefly to coals which are thin, and very seldom practised when the coals are seven feet thick; from four to five feet is reckoned the most favourable thickness for going on comfortably, when attended with ordinary circumstances, as to the kind of roof, pavement, &c.

When a pit is sunk to a coal where this method is to be adopted, the first consideration is, the situation of the coals which lie above the lowest one sunk to; if they are near to one another, it will be most expedient to work the upper coal first, and the others in succession downwards; but if they are about eight fathoms or more apart, with strata of strong composition betwixt them, the working of the lower coals first will do no injury to the upper coals, excepting the breaking of them a little more than usual. In many instances, upper coals are rendered by this operation in a lower coal much easier wrought. When the operation is begun by working in the Shropshire plan, the dip-head levels are driven in the usual manner as before described, and very large pit-bottom pillars formed, as represented Fig. 2. Plate CCCXCII. Along the rise-side of the dip-head level, chains of wall or long pillars are also formed, from eight to ten yards in breadth, and only mined through occasionally for the sake of ventilation, or the forming of new roads. In other instances no pillars are left upon the rise-side of the level; but in place of these, buildings of stone are formed four feet broad in the base, and nine or ten feet from the dip-side of the level; and although the roads are formed nine feet wide at first, they are reduced to half that width after the full pressure of the strata is upon them. When these points are secured, the operation of cutting away the whole of the coal commences. The place where the coal is taken away is named the gob, or waste; and gobbin, or gob stuff, is stones and rubbish taken from the coal, pavement, or roof, to fill up the excavation as much as possible, so as to prevent the crush of the superincumbent strata from making heavy falls, or following too hard upon the workmen. Coals which are wrought in this manner work easiest, according to the way in which the widest backs and cutters are, as explained in the post and stall system; and therefore, in the Shropshire method, the walls are sometimes in one direction and sometimes in another, the mine always turning out the best coals when the open backs or cutters face the workmen.

In many cases, when an immediate and great output of coals are wanted, the walls are carried forward to the rise and also level course on each side of the pit. As roads must be kept through the crushed strata, the miners in the first place cut away about 15 feet of coal around the pit-bottom pillars, and along the upper sides of the dip-head chain-walls; and at the distance of nine or ten feet carry regular buildings of stone three feet broad, with props set flush with the face of these, if necessary. As the workmen proceed forward, they set small pillars of roof or pavement-stone in regular lines with the wall face, and sometimes with props intermediate. In other instances, two, and sometimes three rows of props are carried regularly parallel with the wall-face, the front row being at the distance of four feet from it; as the workmen proceed forward, all the back row of props are drawn, the space adjoining them having been previously filled up with gobbing. These props are placed again next the wall face, so that the process of drawing and setting the props goes alternately forward every day. When the roof is strong, fewer props and stone pillars are placed; but when it is bad, they are set very thick. The intention of the props is for the security of the workmen, to keep up the roof-stone; they have no effect in resisting the crush of the superincumbent strata. When the gobbing is scarce, and the roof strong, it has been found a good plan to form the gobbing into wastes, which is, that in place of leaving the gobbing at a distance from the roof, to form it into long heaps at right angles to the wall-faces, as represented Fig, 5. where *a* is the roof, *b* the pavement, *c* the gobbing, and *d* the wastes. As the pressure comes on, the gobbing spreads out, and the wastes are made narrower; yet they frequently remain so open, as not only to form air courses in case of necessity, but they can be crept through to a great distance. There are two principal modes of carrying on the Shropshire system.

The first, or what is properly the original system, was to open out the wall in the manner before described around the pit-bottom; and as the wall-face extended in width, to set off main-roads and branches, very much in the form of the branches of a tree; these roads were so arranged, that betwixt the ends of any two branches there should be a distance of from 20 to 40 yards, according as might be most suitable, as represented in Plate CCCXCII. Fig. 2. Each space of coal betwixt the roads is named a wall; and one half of the coals produced from each wall is carried to the one road, and the other half to the other road; this is a great conveniency when the roof is bad, so that in many instances the distance of 20 yards betwixt the roads is preferred. In the figure, A is the pit, BB the wall-face, *a* the dip-head level, *b* the roads at from 20 to 40 yards asunder, *c* the gob or waste, with buildings along the sides of the roads, and *d* the pillars.

The other Shropshire method is represented in Fig. 14, Plate CCCXCI. where A represents the pit with the bottom pillars; *b* the dip-head levels; *c* the off-break from the level, where no pillars are left; *d* the off-break, where pillars are left to secure the level. All roads are secured in the sides by buildings of stone, if such can be had, laid off 9 feet wide. After the crush settles, the roads are generally permanently good, and can frequently be travelled through as easily fifty years after they have been made as at the first. When stones cannot be had in abundance, coals have to be used, and are built about 20 inches in the base. If schist is used, it requires to be from 2 to 3 feet square. In this method, the roads are also from 20 to 40 yards apart, but in place of branching they are set off in a direction parallel to each other. The workmen secure the waste by gobbing; and three rows of props are carried forward next the wall faces *a*, with pillars of stone or coal built betwixt them. This mode is more regular than the former, though not in such general practice.

The coal, when wrought in the Shropshire method, is carried on by the workmen very differently from the post and stall system, where each man has his own room, and performs all the labour. The Shropshire method is carried on by the division of labour performed by different sets of workmen, generally divided into three companies. The first set, curves or pools the coal along the whole line of walls, laying in or pooling always at least 3 feet, and frequently 45 inches, or five quarters, as they term it. Their work is measured as to length and depth by the oversman, the depth being gauged by an iron instrument, named a jack, 40 inches long, the knee of which must reach the wall face, if the curving is full; if short, the workman must complete it. These men are named Holers. As the crush is constantly following them, and working over their heads, which frequently has the effect of making the coal fall above them, for their security, props of wood are set at regular distances in an oblique direction between the pavement and wall face. Besides these, for farther security, staples of coal, about 10 inches square, are left at every 6 or 8 yards distance, until the line of holing or curving is completed. The walls are then divided into spaces of from 6 to 8 yards in length; and at each of these spaces a shearing or perpendicular cut is made as deep as the holing, and when this is done, the holer's work is completed. The next set of men who succeeds the holers are the getters. These begin at the divisions of wall at the centre, and drive out the gibbs and staples. They then set wedges along the roof, and bring down each division of coal progressively; or, if the roof is very bound, the coal is blown down with gunpowder. It frequently happens, when the roof has a good parting, the coals fall down the instant the gibbs are struck, which renders the work very easy. The getters are relieved by a third set of men, named butty-men, who break out the coals into pieces of a proper size for sending up the pit, and have the charge of turning out the coal from the wall face to the ends of the roads. When this is done, they build the stone pillars, fill up the gob, set the trees, clear the wall-faces of all obstructions, set the gibbs, and have every thing clear and patent for the holders recommencing their work. If the roads are to heighten, by taking down the roof, or lifting the pavement, these butty-men perform this work also, build forward the sides of the roads, and secure them with props when necessary. When both pavement and roof are hard, and the coal above 4 feet thick, a greater proportion of coal is lost by securing the waste, than when the pavement is moderately hard, or the roof easily taken down, as these afford plenty of gobbing. Frequently nothing but the large pieces of coal are taken out for the market, all the smaller parts of the coal and culm being required for the gob, besides a proportion of the great coal for the small pillars. When a coal has a following or roof stone, which comes regularly away with the coal, this renders the work easy, and saves much coal; and when it happens that a soft bed of fire clay is found a foot or two under the sole of the coal, the holing is made in it, and the stone betwixt the holing and the coal benched down, which serves for pillars and gobbing. By this plan all the vendable coal is saved.

The chief caution required in the management or conducting the Shropshire method, is the off-break from the pit bottom and levels, to produce the first break of the strata; the more the waste is filled with gobbing, the less is the risk of any misfortune to the works or the miners. When the superincumbent strata are strong, with thick beds of sandstone near the coal, the waste will sometimes advance many yards before the break takes place; and when it commences, which is known by the great noise heard over head, the greatest care is required, to prevent the crush making a break, or nipping along the face of the whole wall, which sometimes happens. This is termed *the wall coming in*; that is, the strata come down along the whole line of the wall faces, and shut up every opening. The consequence of which is, that the faces have all to be opened out again along the line of the break, and to the rise of the broken rock face. If, during the course of the ordinary working, when the crush comes regularly and progressively forward, care is not taken to keep the gob well and regularly filled up, in the manner already mentioned, the coming in of the wall is almost the certain consequence.

As to the setting of props, and the building of pillars in this work, if the roof and pavement are both very strong, the pillars of stone are built as usual, but not made very firm by any kind of wedging; and in place of setting the props firm betwixt the roof and pavement, it is of advantage to place under each a bit of stone, or small piece of waste wood, the object here not being to resist the absolute pressure of the strata, but to keep up the roof stone for the safety of the men, until the strata press down and rest upon the gob; for if, in this case, small pillars of coal were left in the working in place of built pillars, or the props set very firm, the consequence would be, that the instant the least pressure came forward, the coal pillars would fly to pieces, every prop would be instantly broken, the roof come down, and the workmen be killed; whereas by the pillars and props yielding gradually, until the gobbing receives the pressure, all points are kept right, and the props are saved for farther service. In Shropshire, some collieries use a great proportion of cast-iron props. This plan is a saving, when an iron work is connected with the colliery, that when a prop breaks it is recast at little expence, but in ordinary cases the expence will be found too great. When props will not drive out by applying the force of heavy mauls, a long chain with a hook is provided, the hook is fixed to the bottom or top of the prop, and the other end, having a small hook, is doubled up to form an eye or loop, which is passed over a strong lever of iron or wood, the point of which resting against a firm prop, gives the workmen great power in wrenching the other prop from its place.

Another modification of the Shropshire method is, for each workman to have from 6 to 12 feet of coal before him, with a leading hand man, and where every workman follows in succession like the steps of a stair. If the coal has open backs and cutters, this work goes on very regularly, as represented in Fig. 3. Plate CCCXCII. where the leading hand is at *a*, next the crop, and *b b*, &c. are the wall-faces of each workman, A the pit, B the dip-head level. In this case the roads are either carried progressively through the gob, or the gob is altogether shut up, and the whole of the coal are brought down the wall-faces, either to the dip-head level or to the road *c c*. This method may be varied by making the walls of a breadth to hold two, three, or four men; by this plan each set of men performs the whole work of holing, getting, breaking out, and carrying away the coals. This mode can be also equally well adopted by working the coals level-course with the leading hand next the dip-head.

It may be estimated, that from an eighth to a twelfth part only of the coal is left under ground by the Shropshire system, and in favourable instances every inch of coal can be taken out, the principle being to leave no solid pillars, or any coal below, excepting what may be indispensably requisite to secure the gob. This system might be applied to coals of almost any thickness, providing stuff could be got to fill up the gob. It is the want of it which limits this system to coals of a certain height. Various modifications of the systems now described are in use, but it would be endless to describe them; the general principles are the same; *The object and intention being always to produce as much coal as possible from a given area, as may be consistent with the safety of the workmen*, having all other circumstances as before mentioned in view.

Such being the general modes practised in Great Britain, of working coals of ordinary thickness and of moderate dip and rise, a general description will now be given of the methods pursued in working coals of the following description:

1. Very thin coals.
2. Very thick coals.
3. Coals having a great dip and rise, or what are termed edge coals.

Beds of coal in Great Britain are wrought as thin as 18 inches as a coal mine; if wrought thinner, the working of fire-clay or iron-stone immediately adjoining is connected with them. There are, however, instances of caking coals, of a fine quality for smiths, being wrought alone, only 12 inches in thickness. When the bed is 18 inches in thickness, it can be wrought by men of the ordinary size, but young men and boys are more suitable. Coal of this thickness can be wrought without lifting the pavement, or taking down the roof in the rooms; but for taking out the coals, roads are cut either in the pavement or roof. All coals under two feet three inches in thickness are wrought with the intention of taking out all the coal, either in the Shropshire system, or with pillar-walls and rooms; with this difference, that from the thinness of the bed the rooms are wrought as wide as the roof will carry up, or if a following or fall of the roof-stone can be brought on, it is an advantage, as it not only gives height, but, by filling up the waste, renders the roads easily kept for the working of the pillars. Where there is no following, small temporary pillars are left, about eight feet square, along the chain-wall side. The walls are from four to sixteen yards in thickness, according to circumstances, and only holed through occasionally for air. The rooms 20 feet in breadth, with the small pillars set six or eight feet from the pillar side or chain-wall, and eight feet apart from each other. When the workings are carried to the required extent, the chains of wall and small pillars are begun to be wrought at the most distant point, and finished off at the pit-bottom. Of this method there are also various modifications, depending upon the texture of the coal, the kind of roof, pavement, and superincumbent strata. The common post and stall work is not suitable for such thin coals, particularly as a given area yields so small a quantity of coals.

Coals which are from five to eight feet in thickness are the most suitable in every point of view for the full effective exertion of the miner, and for the general economy of under-ground operations. When they much exceed this height, they require very excellent roofs and pavements, to render the work safe and comfortable, or to enable those who direct the mining operations to take out a fair proportion of coal from a given area. In these thick coals the Shropshire method is impracticable for want of gobbing, and the length of the props would present but a feeble resistance to the pressure of heavy roof stones.

When coals do not exceed 20 feet in thickness, and have good roofs, they are sometimes wrought as one bed of coal; but if the coal is tender or free, it is wrought as two beds. In general, however, nearly a half of the coal is lost in pillars, and very seldom can less than a third be left. In working such a coal as one bed, two modes are adopted.

The first is, to work the roof-coal to the thickness of from four to six feet, the length of a pillar and thirling, and four feet more; then the ground coal is wrought as a bench under foot by the partings, as an open cast quarry above ground; but before the ground-coal is taken down opposite the thirling, the thirling is set in four feet in the roof-coal, and then the whole of the ground-coal is wrought away; this leaves a bench or seat of four feet broad in the forehead of the room, and in the mouth of the thirling, for the collier to stand on when he commences to work the roof-coal either in the room or thirling. Without leaving this bench, a scaffolding of timber would require to be erected for commencing his operations again.

The other method is, to work a portion of the ground-coal first, of from three to five feet thick, the length of the pillar and thirling, and then returning to the face, work the upper part of the coal overhead.

When the coal is free, and ready to crumble by the pressure and effect of the air, the upper portion of the coal is first wrought, then a scaffolding of coal is left, from two to three feet thick, according to the texture and quality of the coal; and the lower part of the coal is then wrought as represented in Fig. 4. Plate CCCXCII. When the workings are completed to the proposed extent, the scaffoldings of coal are wrought away, with the part of the pillars that can be removed with safety.

As the using of prop-wood in coal of so great a height is not found practicable, and as falls in the roof would be so exceedingly fatal to the workmen, if the roof is in the least degree tender, it is the practice in such cases to leave a roof of coal from two to three feet in thickness. This of itself not only makes an excellent roof, but, when it is breaking, gives warning by the noise it makes, so very different from the noise of roof-stones when they are giving way.

One of the thickest coals in Great Britain, which is wrought as one bed from roof to pavement, is the very remarkable coal in Staffordshire, close to the town of Dudley, known by the name of the ten-yard coal, a section of which, with the accompanying strata, is given in the preceding part of this treatise: this wonderful bed of coal is in extent about seven miles long, and four broad. No coal similar to it has been found in the island, and the mode of working it is altogether singular. It is wrought in a kind of pannel work, but altogether different from the improved Newcastle system.

Numerous pits are used in working a coal-field even of moderate extent at Dudley: and in place of one pit, with one corve ascending and another descending alternately, as in other collieries, two pits are always sunk, from ten to thirty feet apart, and from six to seven feet diameter, of a round form; for these two pits, one coal-drawing engine is employed, having a rope into each pit, the object being to draw the coals with a very slow motion, but a great weight of coals each time. A pannel or compartment formed in working the coal is named a side of work; and in each side of work sometimes only two pillars are formed. In other cases there are four, six, nine, or twelve, but the last number is very seldom adopted; two or four pillars in a side of work left for the support of the roof is the common practice, and what is most approved of. As the whole operation of working this coal is performed in one of the compartments, named a side of work, it will be proper to explain the mode of working out the coal from one of these, before describing the whole extent of the workings of a pit.

Fig. 1. Plate CCCXCIII. represents a side of work; A, the ribs or walls of coal left around, and forming the side of work; *a* the pillars, 8 yards square; *c* the stalls, 11 yards in width; *d* the cross openings or through puts, also 11 yards wide; *e* the bolt-hole cut

through the rib from the main road, by which bolt-hole the side of work is opened up, and all the coals carried out. There are two, three, or four bolt-holes opening into a side of work, according to its extent; they are about eight feet wide, and nine feet high. As the coal is divided into subordinate beds by common coal partings, or by bands of stone termed batt, of from an inch to above a foot in thickness, though in some instances bands are many feet thick, the working is in a great degree regulated by these divisions. Although the coal is 30 feet thick, the lower band, which is 2 feet 8 inches thick, is wrought first, the workmen choosing to confine themselves within this narrow opening, in order to gain the greater advantage afterwards in working the coal immediately above; as soon as the workmen cut through the bolt-hole, they open up the work by cutting a mine forward, four feet in width, as represented by the dotted lines. At the sides of this mine, next the bolt-hole, each workman in succession breaks off a breast of coal, two yards broad, as at *f f*, by means of which the sides of the rib-walls A are formed, and the area of the pillars. In this manner each collier follows another, as in one of the systems of the Shropshire method before described. When the side of work is opened out along the rib-walls, and the faces and sides of the pillars formed off, the upper coals are then begun to be wrought next the rib-wall, which is done by shearing up to a bed next the bolt-hole, and on each side, then the head coals are brought regularly down in large tabular masses, of such thickness as suits best with the free partings or subordinate divisions of the coals and bands, the shearings are made very wide when they require to be put up five or six feet, as in this case they must admit the head and shoulders of the miner. For the security of the workmen, props of wood are used to support the first of the upper coals, and temporary pillars of stone are also built at convenient distances; these are termed cogs. Besides these safeguards, if the mass of coal to be brought down is great, square spurs or spurns of coal are left, about 10 inches thick, at the lower part of the shearing, and at various distances, until the shearing is completed; the props and cogs are then withdrawn, the back spurns are cut away in succession, until the front ones are also cut away, then the cogs and props at the lip of the hanging coal are driven out, when the coal falls in a body, breaking off by the ends of the shearing. Besides the main pillars represented in the figure, temporary and intermediate pillars are formed, of from two to three yards square; these are termed *men of war*. In the first workings of the ten yard coal, these temporary pillars were formed when carrying forward the work in the coal next the pavement, but this was found not only a hindrance in carrying forward the work in the first opening, but, as the sides of work were extended, a certain degree of pressure came upon the work, when these pillars, or men of war, instantly gave way and were of no use. Experience has taught the miners a remedy for this, which is, to form none of these pillars until the first of the upper coals begins to be wrought, when square basements of stone are formed on the pavement at the places where the men of war are to be, of an area some inches or a foot larger than the intended size of the pillar; and when the building is within three or four inches of the coal, that space is filled up with pieces of wood, made moderately firm; the effect of this is, that when the pressure of the superincumbent strata begins to bear upon the whole of the pillars, the pieces of wood and under-building yield by degrees, and prevent the pillar of coal above from giving way. This principle is found effectual, and could only have been discovered in the course of much previous practice; it is a principle which is applicable in many instances to mining operations, when a degree of yielding to the pressure is more efficient as to ultimate resistance, than a rigid resistance at once applied. In this manner, about half the thickness of the coal, or rather more, is brought down in tabular masses of various thickness, having the men of war pillars left for the last of the work, which is taking down the coals next the roof; these are brought down in immense falls, of from 100 to 200 tons at a time, and in some instances even 300 tons. When the various sides of work in a pit-workings are in a prepared state, that is, prepared for taking down the upper coals, sometimes there are 6000 tons in this way ready to fall.

In the course of working and breaking out the coals for going up the pit, all the culm-coal, and a great proportion of excellent small coals, are left in the waste, upon which the colliers stand when working the upper coals, and when the height becomes great, ladders and various kinds of scaffolding are used. The last of the upper coals, in place of being wrought from the bolt rib wall forward, are wrought from the opposite rib wall towards the bolt rib, for the safety of the workmen. This operation is attended with great danger to the workmen, and therefore they are required to be very expert miners from practice in that kind of work, with much boldness and resolute determination. The first operation is to shear along the face of the back rib wall, and along the side ribs, leaving spurs at regular distances; the scaffolds are then withdrawn, the men of war cut away as the miners retreat; and the last operation is cutting away the spurs. As the danger is very great working under so large a mass of coal, no miner can approach to cut these away with a common pick; they are therefore provided with an instrument or tool named a pike, very like a boarding pike, 18 feet long, the shaft of wood, having a steeled iron sharp pike, with a hook at the one side, similar to a boat-hook. With this, the miners standing with their backs to the bolt rib wall, cut away with the point of the pike in the advance stroke, and with the hook in the back stroke, the side spurs next the back rib wall. In this manner the spurs are cut away in succession, the miners retreating towards the safe part of the mine, until all of them are cut. Sometimes the coal falls before all the spurs are cut, and before the last of the men of war are cut down; in many instances the upper coals do not only fall the height of the shearing, but up to the roof, by which masses of coal, from 10 to 14 feet thick, fall at once, and not only so, but immense pieces of the strong roof stone fall at the same time, of such a thickness, that before the coal can be broken out, the miners have to blast it with gun-powder, and remove many tons of it. From this description of working the ten-yard coal of Staffordshire, the very dangerous nature of such work may be conceived; but no correct idea can be formed of the operations, or of the immense excavations and caverns formed by the working of the coal, and particularly by the fallen roof. The accidents which take place in this coal are consequently very many; severe contusions and broken limbs are of frequent occurrence, and not a few workmen are snatched from life to death in an instant by the coals and roof falling when they least expect them; but, besides the danger arising from these falls, they have also inflammable air to contend with, by which also many have been killed.

Various modifications of the mode of working a side of work in this coal are practised, as best suits the nature of the coal, the superincumbent strata, the various local circumstances, and views of the manager of the colliery.

When the crop of this singular coal was first wrought, the miners only extended their operations to 20 yards distance all around the pit bottom, and then began a new pit; but as the pits became deeper and more expensive, the distance of the workings was extended, and the method of mining improved. The extent of a pit's workings is now in general 100 yards on all sides, that is, the area wrought is 200 yards upon the side, and in a number of cases 300 yards, or 150 yards of extent on each quarter of the pit. The greatest distance ever attempted was 450 yards from the pit bottom, but this distance does not appear to be suitable. A number of the sides of work, as of the side of work represented in the figure, constitute the workings of a pit. The roads leading from the pit bottom are from 3 to 4 yards wide, and the rib walls are of various thickness; the main ribs being 12 yards, the others about 5 yards in thickness.

This coal, in the course of working, is, like many, liable to take fire by spontaneous ignition, which is not only exceedingly dangerous and troublesome, but requires the greatest attention to prevent its formation. It is here termed the breeding fire, and will be treated of when stating the accidents to which coal-mines are liable. It is this which requires the workings to be laid off in sides of work, as represented in the figure, with one opening or bolt hole, which is securely built up and made air-tight as soon as the side of work is wrought out. When a pit is wrought to its full extent, then, if circumstances admit of it, it is wrought in the pillars and ribs, beginging at the most distant corners, and as much of the pillars and ribs are brought away as can be done, consistent with the safety of the workmen. If there are openings through the ribs to any other pit workings, they are carefully built up with double walls of stone, a few feet asunder, and the space is filled up with mine dust, (the refuse of calcined ironstone;) which mine dust is found the most effectual remedy for keeping the passage air-tight, in the event of a crush rending the walls, as the mine dust yields to the pressure without admitting the air to pass.

From this description of working the ten-yard coal, it is evident that a very great proportion of the coal is left under ground, not only in pillars and rib-walls, but there is an uncommon quantity of small coal produced in the operation of bringing down, and breaking out the coal, so that in general from four-tenths to a half of the whole is for ever lost; and it is also evident, that from the long habit of the workmen, it would be almost impossible to introduce any new method, though, to all appearance, it would be decidedly preferable to the present system. One plan has been suggested, which was, to work the upper part of the coal first, leaving a few feet of coal for a roof, and then work all the lower coals in benches, as described in the working of coals 20 feet in thickness, the roof to be supported with props. It is however questionable, how far this would be found in the end better, or whether less small coal would be produced.

The next method of working coals of uncommon thickness is by stages or scaffoldings of coal, as practised in that coal of astonishing thickness found at Johnstone, near Paisley in Scotland, and represented in the sections in the first part of this treatise, being from 50 to 60 feet thick in one quarter of the field, and in one part no less than 90 feet thick. There are, no doubt, several thin bands of stone in it, but there are only two of 27 inches thick each. The roof of this coal is so bad, and the height so great, that it was found quite impracticable to work it as one seam, as in Staffordshire; and therefore the method is, to leave about three feet of the upper coal for a roof, then to work a band of the coal from six to seven feet thick, as best suited the partings of the coal, or thin bands of stone, which band of coal is wrought in the post and stall system, with square pillars of extra strength, which are cut through afterwards. A scaffold or stage of about three feet thick of coal, or of coal and band stone, is left at the sole; and under this, rooms and pillars are set off and wrought in another portion of the coal, from five to seven feet thick, great care being taken to place pillar under pillar, and room under room, to prevent a crush. In this way, when the coal is thickest, 10 bands of coal are wrought, in the manner represented in Fig. 2. Plate CCCXCIII. When any band of the coal is foul, or of a quality not suitable for the market, it is given up, and allowed to remain along with the next scaffolding; a great proportion of the coal is consequently lost, as in the Staffordshire thick coal. The working of this coal requires very assiduous attention to keep the pillars and rooms in a perpendicular direction; the miners' compass has to be used daily, and bore-holes have occasionally to be put down through the scaffoldings of coal, that the pillars may be placed correctly under each other.

Having thus described the general modes or systems which have been adopted in working coals of various thickness, the system adopted in working coals which are named half-edge coals, and edge coals, shall next be described.

Half-edge coals are wrought either post and stall, or in the Shropshire system, as before described, with this difference, that the rooms are always, if possible, carried in a level course direction, for the safety of the workmen, and the more easily taking the coal to the pit bottom.

The working of edge coals, which are nearly perpendicular, are wrought in a peculiar manner, and different from any of the coals before described, as the collier, while working, stands upon the coal, having the roof upon his one hand, and the pavement upon the other, like two walls of stone. The engine-pit is sunk in the strongest of the strata, and in some instances, they are so directly vertical, that the same stratum is sunk through the whole depth. After the pit has reached the required depth, mines are carried across the strata from the pit bottom, until the coals are intersected, as represented in Fig 3 Plate CCCXCIII. where *a. a*, are the edge coals; A the engine-pit; *b. b*, the cross cut mines from the pit bottom; *c, c*, upper cross-cut mines for the greater conveniency of working the coals. All the rooms are wrought in a level-course direction, with openings made from one to another, for air and access to the pit bottom. The chief edge-coal works in Britain are in the vicinity of Edinburgh, where hitherto all the coals in such works are carried upon the backs of women from the wall face to the pit bottom; and, in general all the pits of a colliery, excepting the engine-pit, are only sunk one half the depth of the breast of coal to be wrought, in order that one half of the rooms may have their coals carried up to the pit bottom, and the other half carried down. This is effected by wooden traps or stairs, placed from one room to another. It is singular that no improvement has been yet made of this very rude plan; particularly as the edge coals are wrought at a great expence, and with great inconveniency.

Although various modes and systems of coal working have been described, there are very many modifications in all of them, which are regulated by the consideration of local circumstances joined to years of experience. These alone can determine the mining engineer as to his adopting the system best suited for working the coals in a coal-field.

With regard to the manner in which coals are brought from the wall face to the pit bottom, this is almost as various as the systems pursued in working.

The oldest mode, and that which it is presumed was used when coals were first wrought by ingoing eyes, or mines at the crop, was by women carrying the coals in baskets on their backs. This method, rude and severe as it is, was carried on very generally in Scotland till within these forty years; and it is to be regretted that a system so slavish and severe is even in this age (which boasts of being enlightened) adopted and carried on. It is admitted that it is a matter of free-will, and those women who carry coals may give it up if they choose. To young women the severity of the labour is less to be considered, in one point of view, but to the mothers of families the system is oppressive, deprives them of many comforts, and precludes them from advancing in their own scale of society. This system is, however, declining every year; and, on this account, no description is given of the arrangement of the workings of a colliery which are peculiar to this method.

The women who carry coals are named bearers; the weight each carries is from 1 cwt. 1 qr. to 2 cwt; in some instances they have carried 3 cwt. In the worst kinds of this system, they not only carry the coals from the wall face to the pit bottom, but ascend a stair to the top of the pit, and bank the coals. In the other case they carry from the wall face, and lay them down in bins at the pit bottom, in order to be filled into the baskets. In some collieries 60,000 tons annually have been carried in this way, and an extent of 160 yards from each quarter of a pit has been wrought by this plan, which is an area of 102,400 yards.

The next mode is to use hutches or baskets with slipe or cradle feet shod with iron, containing from 2 to 3 cwt. of coals. These are drawn along the pavement either by ropes and soams, or by harness of leather, over the shoulders of the workmen. The collier either performs this work as part of his daily labour, or persons are appointed for this work alone, and are thus drawn from the wall face to the pit bottom. This system is used in many small collieries, but it is among the worst plans; for in no instance can the strength of a man be applied with less effect than in this way; the exertion required is very great and unceasing, nor does any extra exertion of muscular force aid him the least in the next step of his labour; it is from beginning to end one continued dead pull, without the least spring or elasticity; and if he slackens his exertion one instant, the weight he is dragging that instant stops. It is painful to see men thus employed, and their strength so evidently misapplied. This system must daily decline.

The third method, as an improvement of the last, is to substitute hutches, or baskets, capable of containing from 4 to 6 cwt. of coals, and of the same form as those above described, but, in place of men horses are employed to draw them from the wall face to the pit bottom. This is also a very bad system; the same objections are applicable to it as to the former, and the strength of a horse is applied with the very worst effect.

The next improvement upon the system where men draw the coals, was either to set the corve on a small four-wheeled carriage, named a tram, or to have wheels attached to the corve. By means of this, more work was performed, provided the pavement was hard, but it was not applicable when the pavement was soft; in which case, an irregular kind of wooden rail-roads was laid.

When the distance from the pit bottom became considerable, regular and well laid wooden rail-ways were laid to a point near the wall faces, named the way-end. To this point the coals were brought down in the corves, either by men who draw the trams, named trammers, or by horses upon slipes. Upon the rail-way there were strong four-wheeled frames or carriages capable of holding two corves. At the way-end a small crane, with a wheel, pinion, and chain, was erected. With this the corves were lifted from the trams, and placed on the carriage; two or more of them were then hooked together, and one horse drew to the pit bottom from four to six corves at a time.

The whole system of bringing coals from the wall face to the pit bottom was greatly improved by the introduction of cast-iron rail-roads, named tram roads, in place of wooden roads. For this great improvement, we are indebted to Mr. John Curr of Sheffield, in Yorkshire, who first brought it forward. This system is universally adopted in all collieries of any considerable extent, and is equally applicable to the smallest mining concerns. The rails are named tram-rails, or plate-rails, it being a plate from three to four inches broad, with an edge at right angles to it, about two and a half inches high, and are from three to four feet in length. They are fixed either to cross pieces of iron named sleepers, or more generally to wooden sleepers; the strength of the rails being proportioned to the weight carried. For particulars regarding the construction and weight of these roads, see the article RAIL-WAY.

By this system, in some collieries, the colliers, after having wrought the coals, draw them along the tram-roads to the pit bottom. In other works, persons are employed to draw the coals, named trammers, when one in front of the corve draws with harness, and one pushes the corve behind, who is known by the name of a putter. The perfection of this system is to be seen in the Newcastle collieries, and in the collieries of Whitehaven and Workington in Cumberland. The main roads or rolley-ways, also named mother-gates, are laid from the pit bottom to a convenient central point near the wall faces or rooms where the colliers work. There a crane is erected. From this point tram roads are laid into each room. In bringing the coals from the wall face to the crane, a stout lad and a young boy are employed at each corve. The lad, who is in front, and draws, is named a headsman, and the boy is named a foal. As many of these are employed in a set or sheth of rooms as will keep the crane and rolley-way in constant work; the instant each corve arrives from the wall face at the crane, it is lifted from the tram, and placed on a rolley, each rolley holding generally two corves: Single corve rolleys are sometimes used, and as soon as three or four double rolleys are loaded, they are hooked together, when a rolley-driver, with his horse, takes them to the pit bottom, while the loaded rolleys are going to the pit. Rolleys with empty corves are returning, and these pass the loaded ones at given regular distances, where the rail-way is double, named an off-set, or pass-by road. The rolley horses, to prevent the carriages overrunning them, have a peculiar kind of shafts, named limbers, either made of wood or iron, but commonly of iron, as represented in Fig. 4. Plate CCCXCIII.; the hole at *a* passing over an iron stud in front of the rolley, and are quickly attached or detached. In this manner the work is carried on with astonishing regularity and expedition. The power of the engine for drawing the coals is constructed in proportion to the depth of the pit and quantity to be raised, taking two corves at a lift, and going at a velocity in the pit of 12 feet per second, on an average; and so very regular and systematic is the arrangement of this operation, that the corves are brought forward from the wall faces to the pit bottom, and sent up the pit as fast as the on-setters at the pit bottom, and the banksmen at top, can hook and dishook the loaded and empty corves to and from the engine ropes, so that 100 corves of coals every hour has been drawn up a pit 100 fathoms deep, which is equal to 27 tons per hour, or 324 tons in a day or shift of 12 hours. In short, any requisite quantity may be drawn up a pit by this highly improved system. It must, however, be remarked, that this system is more applicable to coals similar to those of Newcastle, which work small, than to coals which work in large masses, and which must be kept large, to suit the market, on account of their open burning quality.

When coals have so great a rise from the pit bottom to the crop, that horses cannot be applied on the rolley ways, the corves descend along the roads by means of inclined plane machines, which machines are either vertical rope-barrels, or horizontal rope-sheaves. The descending motion is guided by a brake, and while six or eight loaded corves are descending, as many empty corves are ascending. These inclined planes are either of great length, or divided into stages of from 200 to 300 yards long. At the end of each stage is an inclined plane machine, so that the coals are lowered in succession from one machine to another. The corves are brought from the wall faces to the planes either by men or horses. The whole of the system of bringing coals from the wall faces to the pit bottom, can be modified to suit the extent of any colliery. Inclined planes are much used at Newcastle, when the dip of the coal admits of it.

The wheels of the trams and rolleys, are from eight to sixteen inches in diameter, according to the thickness of the coal. In some, the axles not only turn round on their journals, but the wheels also turn round upon the axis; in others, the axles are fixed, and the wheels only turn round; and there are some which have the wheel fixed upon the one end of the axle, and the opposite wheel made to run round it; and the other axle has the fixed and loose wheels upon the reverse sides, the intention being to make the carriages go easily round the turns of the road.

With regard to the drawing of coals up the pits, various kinds of machines have been applied.

In shallow pits, where there is very little output of coals, the common windlass, or jack roll, with two men, is still used. In deeper pits, the common gin is used, or the wheel and pinion gin; these, however, are only applied at collieries of small extent, and every other machine for drawing coals has been superseded by the rotatory steam-engine with fly-wheel, fly-wheel shaft, and rope-barrels. These engines are of every variety of construction, and of Newcomen's, Watt's, and Trevethick's principles. They are applied from the power of three horses to that of forty. When they are of small power, they are generally constructed with a fly-wheel, and short fly-wheel shaft, upon which is a small pinion working into the teeth of a large wheel, fixed upon the rope-barrel, by which means the engine goes with great rapidity, while a slow and equal motion is produced in the ascending corves in the pit. But when the engines are of great power, and much execution of work required, then the engine is connected directly with the rope-barrel; and some of these for deep pits are of such a size, that each revolution of the barrel produces an ascent of 13 yards. In short, there seems almost no limitation to the execution of work by these engines. For all great outputs of coal, Watt's engine is in the most general use. The momentum of these machines is so great, and the fly-wheels are so heavy, and go at so great a velocity, that the mere suspending of the moving principles of the engine would not stop the movements at the instant wanted, on which account a very powerful brake is applied to the periphery of the fly-wheel, or rope barrel, so that the brakeman, by applying his foot to the regulating lever of the brake, while with his hands, he shuts the valves of the engine, can pitch the corve and suspend its rapid motion within a few inches of the required height at every delivery.

Many attempts have been made to apply the steam-engine to an endless chain or chains suspended from the top to the bottom of the pit. Several are in use, but it is questionable how far they are applicable to very deep pits; as they have hitherto been only applied in pits of moderate depth. The best principle we have seen is, that invented by Mr. Hugh Baird, civil engineer, and applied in practice at the Shotts Iron Work, which, though on a small scale, shows the effect most correctly. Two endless chains, having long stave links, are suspended from two barrels placed over the mouth of the pit. The diameter of the barrels is more than double the depth of the hutch; and to keep the chains regular, they pass under other barrels beneath the scaffold of the pit bottom; studs of iron project from the inside of each chain, at regular distances, according to the power of the engine, and the hutches have ears of iron, by which they are suspended on the studs of the chain. Upon the end of the chain-barrel is a toothed wheel, into which a pinion works, placed on the fly-shaft of the engine. The chains have guides to prevent them going off the barrels, and there are studs on the barrels which enter into the links, and prevent the chains slipping round, so as to keep the studs upon the sides of the chain exactly opposite and parallel. When the engine is set in motion, the chains ascend on one side and descend on the other. The loaded hutches, as they come to the pit bottom, are set forward, till the ends of them, having the iron ears, are in a line with the perpendicular of the ascending chain, the studs of which catch the ears and carry the hutch up the pit, which passes over the axle of the chain-barrel, and is set down on the strike-boards at the side of the pit. The empty hutches are attached in the same manner at the ascending side of the chains at the pit mouth, go over the barrel, and descend to the bottom. For attaching the empty hutches and detaching the loaded ones, there are moveable strike-boards, which are wrought by a mechanism attached to the machinery. The execution of this machine is very considerable with an engine of moderate powers, as the engine never stops from the beginning to the end of the day's work. Plate CCCXCIV. Fig. 11. shows the hutch passing over the axle at the pit top.

The other kinds of machines are those where water is the moving power. The oldest and most simple is a water-wheel, or rather two water-wheels joined together by the sides, the buckets set reverse to each, so that when water is applied on one side of the wheel, the wheel turns forward, and when applied on the other side, it turns backward. To the axle of the wheel a rope-barrel is attached, or a second power may be produced by a pinion and wheel, as in the steam engine.

The other kind of water engines for drawing coals, is strictly applicable only in pits level free, where the ascent of the loaded corve is produced by a descending cassoon filled with water. When the ascent and descent of both are equal spaces, then the rope-barrel for the cassoon and for the corves are of the same diameter; but when the pits from where the coals are drawn, are deeper than the point of discharge for the water into the dry-level, then the cassoon is made large, and its rope-barrel much smaller than the barrel for the corve-rope, so that by the time the cassoon reaches the half depth, for example, the corve may have ascended double the depth. The cassoon is filled by a valve at the pit top, and upon its reaching the place for discharging the water, a self-acting valve lets it off. The loaded corve is taken off at the pit head, and the descending rope and empty corve pull up the cassoon with ease, on account of its being suspended from a barrel much less in diameter. All the motions of this machine, which would be very variable and destructive, if left to itself, are regulated by a very powerful brake at the pit top.

As much coal and many corves are destroyed by the corves striking at the meetings, where the ascending and descending velocity together is equal in some cases from 20 to 30 feet per second, various plans have been devised to obviate this loss. One of the simplest plans is to divide the pit from top to bottom, so that each corve has a distinct pit for itself.

A second mode was invented by Mr. John Curr, Sheffield, which was to have guides of wood attached from top to bottom of the pit; these are long pieces, or spears of fir wood, about four inches square, attached perpendicularly to the sides of the shaft, and to buntons in the middle of the pit. Betwixt these guides, sliders with friction-rollers are placed, attached to the gin-ropes, and to these sliders the corves are suspended. By this plan the corves or hutches can be drawn with great velocity; but there is a considerable hindrance in striking or banking the corve at the pit top, as shutters or sliding boards have to be used. This plan is not applied in the Newcastle practice, but is highly beneficial where large coals have to be raised. A third mode, of a simple form, is to suspend four chains from the pit-head frame, or round rods of iron screwed together in pieces of 12 or 15 feet each; these are fastened to a strong beam or cill at the pit bottom, and are kept tight by a regulating screw at the top. The slider used for the chains or iron rods, is a double-eyed bolt or rod. Though these are in practice in pits of moderate depth, they are never applied in pits of a great depth.

In drawing coals, both ropes and chains are employed.

The round ropes are shrowd laid; and the best are those made upon the correct mechanical principles, invented by Mr. Chapman and Mr. Huddart, all the yarns being laid equally, so as to have uniform tension when the strain is applied.

The other kind of rope is known by the name of the flat rope, which is without doubt the best of any yet invented for drawing coals, and has proved an immense saving compared with round ropes. They are made of four ropes laid horizontally together, and are alternately right and left laid ropes. By this very ingenious plan, the ropes counteract each other in the twist, and hang like a ribbon down the pit; they are connected or sewed together by a small rope, which operation requires very powerful machinery to pierce the cordage. They have this great advantage also, that they are not only very pliable, which saves the heart of the ropes from being broken, but as they lap upon themselves, a very simple sheave suits for a rope-barrel. But the greatest advantage is, that by lapping upon themselves, they act as a compensation or balance against the weight of the descending corve and rope, superseding in many instances counterpoise chains, which are used to regulate the descent in deep pits. For this invention the mining interest of Great Britain is indebted to Mr. Curr of Sheffield, before mentioned, whose inventions and improvements in the mining system are highly important, as must be evident from those already mentioned.

The kinds of chains which have been tried are very various; some are of long links, termed two and three, or three and four, according to the mode of coupling the links together by a bolt. Many very ingenious plans have been devised to make the long links of correct and equal length from centre to centre of the bolt hole; and though these are applied at many collieries, yet the short pudding link chains are those most generally used. They are proved as to strength, and warranted; have given great satisfaction, and are an immense saving to collieries. These chains are now in general use, and for other purposes besides mining concerns. We have, however, to remark, that the colliers have hitherto declined riding by them in the pits, for this reason, that the fault in a rope is easily seen, but a great fault may exist in a link which cannot be observed.

Upon the corves being landed or banked at the pit top, they are either drawn to the bin or pit-heap by horses upon slipes, or by trammers on a tram road, which is now the common practice. When the coals are small, as at Newcastle, the pit head is raised eight or nine feet higher than the common level of the ground, and the heap proceeds from this height outwards from the pit mouth; and if the bins increase, the tram roads are laid upon the bin or heap as it advances outward.

When coals are wrought large, termed great coal, the pit mouth has only a gentle rise from the common level of the coal-hill adjoining, and the coals are built up in walls, piece by piece, the small coal is either thrown into the heart of the walls or bins, or laid apart by themselves, as may best suit the sale of the coals.

Having thus attempted to describe the various plans which have been adopted for working coal mines, a most important point in mining remains to be treated of, which is *ventilation*, or the means which have been adopted for supplying the workmen with atmospheric air, sufficiently pure for the support of animal life, and the flame of the candle or lamp which gives light in the mines.

The coal-mines of Great Britain were, as before mentioned, wrought on a very limited scale, and with comparatively little system, till after the beginning of the eighteenth century. It was not till the introduction of the steam-engine, for drawing water in the first place, and coals afterwards, that the coal-mines began to be wrought on an extensive scale; even to this period, the ventilation of mines was conducted in a very rude, uncertain, and irregular manner, and for many years afterwards. The air courses were confined to the dip-head levels, and wall-faces, or rooms where the miners wrought; the consequence was, that the wastes were frequently full of inflammable air, and became the cause of constant calamities. The only test the miner had, as to the state of air through the works, was by the appearance produced at the top of the flame of his candle, which appearance will be afterwards noticed.

When inflammable air accumulated in the foreheads, the common practice was to fire it regularly; this was done in many collieries every morning. When this air was in small quantity, the person appointed for the service approached each forehead or room, as near as he judged the air safe; then taking a long pole, he fixed his candle in an oblique position to the end of it with a bit of clay, and laying himself flat upon his breast along the pavement of the coal, he gradually advanced the candle towards the wall-face and roof of the mine, until the gas fired, and the blast passed over him. When the quantity of gas was very inconsiderable, it burnt slowly, with a bright blue lambent flame; when the quantity was more abundant it blazed, the greater part of the flame being blue, but fringed with yellowish white flame. The gas, in this case, burnt off with very little noise; but when the quantity was considerable, it ignited with an explosive sound, and then passed quickly off without extending its influence to any considerable distance. When the person who performed this service found the gas abundant, he put on wet jackets, to prevent the fire scorching him. This singular operation had, in many instances, to be gone through in the numerous foreheads of the same colliery every morning, previous to the workmen entering the pit. In other collieries, where this gas was so abundant that it not only accumulated in the forehead of every room during the time the miners were absent, but gathered in a connected body, filling a considerable space, greater caution had to be adopted. In this case, the fireman went amongst the inflammable air in the dark, leaving his candle at a considerable distance; then fixing a prop betwixt the roof and pavement, he passed the end of a long line, through a ring attached to the top of the prop, he retreated to his candle, with the two ends of the line with him, and having prepared a piece of deal, about fifteen inches long, and eight inches broad, shaped like a weaver's shuttle, he fixed his candle in a hole of the board, or by a bit of clay in an oblique direction; then tying one end of the line to the board, he lay down at the end of a pillar, off the line of the air course, and by drawing the other end of the line gently to him, the candle advanced to the foot of the prop, and if the gas was not so low as the pavement, the candle was drawn up towards the roof, when the whole of the gas instantly ignited with an explosion, and passed along the air course within a few feet of the fireman, and directly towards the upcast shaft. In Staffordshire, where the coal is thirty feet thick, and the excavations immense, this method was, till lately, in general practice. In place of a prop, a kind of mast was erected, fixed at the pavement, as the top of it did not reach the roof; and in place of a line, fine flexile copper wire was employed, which was not destroyed by the explosion. In these numerous and very extensive mines, and where the coal was taken down far above the air courses, the collections of inflammable air were great, and when ignited the explosion was frequently violent, and passed the fireman in his retreat, with a thundering noise, and with great velocity. This very rude, and very dangerous mode of clearing the mines of inflammable air, is yet to be found in practice, and is known by the name of the fire, or firing line.

Every bed of coal abounds less or more with deleterious air, which is of two kinds; the one is specifically heavier, the other lighter than common air; the natural consequence of which is, that the one rests in the deepest or lowest places, the other, from its levity, ascends to the highest places of the mine. The first is known by the common provincial names of choak damp, black damp, styth, or bad air; the other is known by the name of foul air, fire-damp, or inflammable air. The one is the carbonic acid, the other the carburetted hydrogen gas of the chemyst.

The precise qualities of the carbonic acid of coal mines, have been comparatively little attended to, as its destroying powers have not operated extensively.

The nature and composition of the carburetted hydrogen have closely engaged the attention of philosophers for the last ten years.

According to the best authorities, these gases are of the following specific gravity and weight.

	Spec. Grav.	Weight of 100 Cubic Inches.
Carbonic acid -	1.518	46.313
Carburetted hydrogen	0.555	16.99
Hydrogen - -	0.074	2.230

The common air being reckoned unity, the temperature at 60°, and barometer at 30 inches.

According to Dr. Thompson, the component parts of carburetted hydrogen are,

Carbon - - - -	72
Hydrogen - - - -	28
	100

In which there is always a mixture of carbonic acid.

It has been found that this gas has its greatest explosive power when it is mixed in the proportion of one part of gas to eight parts of atmospheric air; and when it is in the proportion of one part to fifteen of atmospheric air, a candle burns in it without explosion, but the flame is greatly elongated; it therefore ought to be diluted with common air considerably beyond that proportion, to insure the safety of the workmen.

Various theories have been brought forward regarding the formation of these gases, but more particularly of the carburetted hydrogen: both of them flow or exude from the cutters, fissures, and minute pores of the coal; and when in small quantity in the forehead of a mine in solid coal, they make a hissing noise.

The carbonic acid seldom comes off very suddenly in large quantities. From its weight it is not liable to a sudden change of place, and though it is invisible, its line of division from the common atmospheric air is most distinctly found by approaching it with a lighted candle or lamp; for though the candle burns with its ordinary brightness at the distance of three inches from the carbonic acid, the instant it is placed within this air, it is suddenly extinguished; it produces the same instant effect upon the strongest flame of coals; sometimes the upper part of the mine next the roof has the air perfectly good, while the pavement has a stratum of carbonic acid, of a foot or two in thickness, resting upon it. If a coal has a considerable dip and rise, this gas will be found occupying the lower parts of the mine, of a wedge form, as represented Fig. 5. Plate CCCXCIII. where *a* is the carbonic acid, and *b* the common air. When this gas is agitated by a current of common air, or by falls from the roof, it mixes with the mass of common air, and affects the candle by gradually diminishing the flame; and when a stronger portion of the mixture is entered into, the candle is extinguished, but not in the very sudden manner as before mentioned.

When a mine or forehead is driving in advance of the other workings, and a discharge of this air takes place, it very soon fills the whole mine, if the direction of the mine is in the line of level, and the mine is rendered unworkable until a supply of fresh air is brought to displace it.

As the flame of a candle is a correct index of the presence of this air, the miners have instant warning, and stop their advancing any farther, till means are used to drive it away. Comparatively few lives have been lost by this gas. Those who have perished from its effects, had generally gone amongst it without a candle, and of course were insensible of its presence, till they dropped down from its deleterious effects on the constitution. When men are rendered senseless by inhaling this air, they can be recovered, if brought quickly into good air, but if they remain any time in it, all attempts to recover them are ineffectual. It must be remarked, however, that as the air of these coal mines, which abound with carbonic acid, has always a very considerable mixture of it through the whole of the works, the air in this state is reckoned very salubrious, though mixed with a great proportion of moisture. The workmen who breathe it every day are generally healthy, and it is reckoned a specific in some complaints, it being a common practice to send down children affected with the hooping cough to breathe in it.

The carburetted hydrogen is not found in all coal mines, and is seldom seen where the carbonic acid abounds. It has hitherto been found in the greatest quantity in the coal mines situated in the counties of Northumberland, Durham, Cumberland, Staffordshire, and Shropshire. And from investigation we find, that it is generally much more abundant in coals which are of a fine caking quality, and which have a bright steel grained fracture, than in cubic coals of an open burning kind, and the cubic open burning coals yield spontaneously in general more of this gas than the splint coals. To these general cases there are, however, exceptions, some of them very remarkable; a few of which we shall now notice.

In the coal-fields of England and Wales, there are districts where this gas abounds, and other districts where it is never seen; not only so, but in some extended coal fields it will be found very abundant upon one range of the line of bearing, whereas upon the other range none of it is to be seen, but abundance of carbonic acid.

In Scotland the same general remarks are applicable, there being extensive districts where the inflammable air was never seen, and others where it is very abundant. In the numerous collieries situated upon the north banks of the river Forth, it is only found in one very limited district, and in only two districts upon the south banks of the Forth. In the very extensive coal-fields in the Lothians, south from the city of Edinburgh, it is unknown: whereas in the coal-fields around the city of Glasgow, and along the coast of Ayr, it is found very abundant; at the same time there are coal-fields in that very extensive range, where it never was seen; but where it is not seen, the carbonic acid abounds, as before mentioned.

It has been stated by some, that this gas has only been found in mines which are wrought under the level of the sea; it is admitted that it has been found most abundant in such cases, but it abounds also in districts much elevated above that level.

This air is either formed with the coal, or generated afterwards, according to the opinions of different philosophers. One thing is certain, that as soon as a coal containing this air is wrought, the air exudes from every pore with a hissing sound; if the coal is of close texture, and when a cutter or open fissure is struck, it comes off not only quickly, but with immense force, and with a noise similar to the issuing of steam from the safety valve of an engine boiler. This violent issue of gas is named a blower; and if by accident it is ignited, its force is such, that it will act like an immense blow pipe, and set on fire the coal upon the opposite side of the mine, and also at the mouth of the blower. And there have been instances, where, in working a bed of coal under another coal, with seven feet of argillaceous strata betwixt them, and when the upper coal abounded with inflammable air, this gas, from its elasticity, forced down the stratum seven feet thick, although the mine was only four feet in width. These facts clearly prove that this gas abounds in coal, in a state highly compressed, and consequently very elastic. From this cause it is generally found that the coals abounding with this gas are the easiest to work.

It frequently happens that cutters and fissures in the sand-stone, and other accompanying strata of coal, yield this gas in great quantity; but it is never once doubted but that all this gas flows directly from beds of coal. It has likewise been found uniformly in the practice of mining, that in most cases this gas abounds in uncommon quantity, when the miners approach a great dislocation or slip of the strata, and the fissure of the dislocation yields not only the gas in great quantity, but the issue will continue for years, and sometimes during the whole working of the colliery. This circumstance is easily accounted for, because these dislocations extend from the surface of the rock, to depths hitherto impenetrable. Hence a dislocation with an open fissure connects together every bed of coal to the greatest depth, and gives vent to the inflammable air of each, like a train connecting a number of magazines of inflammable matter together; whereas in the common fair lying coal-field, each body of coal is insulated from the other coals by strata which are frequently impervious both to air and to water. There are instances of coal-fields, where, in working the coals in various beds, a particle of this gas was never seen; yet, upon striking a slip or dislocation, it immediately issued, though seldom in such instances in any great quantity.

It is farther to be remarked, that this gas is not only found formed, and pent up in the cavities and fissures of the coal from which it flows freely, when these cavities and fissures are opened, but it appears to exist also in the minute and invisible pores of the compact body of the coal, especially in the caking coals, which have a bright steel grained fracture; besides which, it is chemically combined with the substance of the coal, which circumstances account, in some degree, for its constant formation in particular cases. In proof of which, we have to state, that after coals of the above description have been exposed above ground to the action of the atmospheric air, if a quantity of them are pounded under water, gas will escape in considerable quantity; which gas is the carburetted hydrogen. A singular circumstance has also occurred within these few years; when loading vessels with these coals, newly wrought, and allowing them to fall into the vessels from a considerable height, gas has been produced in such quantity, that after the hatches were secured, and the ships ready to proceed to sea, the gas has ignited at a candle, scorching the seamen, blowing up the decks, and greatly injuring the vessels.

When pillars of coal are forming below ground, for the support of the superincumbent strata, much gas flows from the fore heads of the boards or rooms; but as soon as the pillars are formed, or the mass of coal insulated from the main body of the whole wall, the issue of gas from the pillars almost instantly ceases; but when, by misfortune, a creep or crush comes upon the pillars by the enormous pressure of the strata, a great flow of gas is produced from the pillars into the waste, an effect which may be compared to the squeezing of water from a sponge.

The gas which exists in the coal in chemical combination, can only be driven off by actual burning in a common fire, or by distillation, to which a high degree of heat is applied, as in the manufacture of gas light.

All caking and open burning coals contain this gas in very great quantity, yet there are very singular anomalies regarding its combination with them. From what is before stated, the fine caking coals yield this gas in greatest quantity in the course of mining; but when exposed to the air it retains the gas in larger proportion than the other kinds of coal, yet on distillation, it yields less gas from a given weight of coal. On the other hand, the open burning coals, which generally yield much less gas in mining, when exposed to the air lose a great proportion of it, so much so, that after a twelvemonth's exposure they burn in a common fire-place with a dull flame, termed dead burning; and, in place of forming a good coke or cinder, produce a great quantity of ashes; yet these open burning coals, if kindled when wet from the mine, burn with a bright vigorous flame, an intense heat, and form a good coke or cinder. The pitch coal, known by the names of bottle, parrot, or cannel coal, yields little, if any, of this gas in mining, whereas in distillation it gives a much greater produce than any other of the coals, and is, on this account, greatly preferred in the manufacture of gas light. This gas being lighter than common air, always ascends to the roof or to the rise parts of the colliery, and where the dip is considerable, occupies the forehead of the mine in a wedge form, as represented Fig. 16. Plate CCCXCIII. Where *a* is the inflammable air, and *b* the common air, in this case a candle will burn without danger, near the point *c*, next the roof, whereas, if it is advanced a few feet farther, an explosion will instantly take place, it being well known, that at the line where the two airs are in contact, they mix and form a fringe of air highly explodeable.

When this gas abounds in the mines, and is mixed in great proportion with the common air, the workmen breathe it without suffering any inconvenience at the time, and although they work amongst it for a succession of years, their health does not appear to be affected by it; but if a miner enters amongst pure carburetted hydrogen, the instant he takes one inhalation he drops down as if shot, and the whole living principles are completely and instantly suspended; those who have seen such an accident take place, were greatly astonished at its instantaneous operation on the animal economy. Persons who suffer from these deleterious effects are recovered, if carried immediately into good air.

As to the formation of these gases in coal, many theories have been brought forward, but none of the conclusions are quite satisfactory.

It is the opinion of many, that the iron pyrites, which abounds so much in many coals, is the cause of the formation of carburetted hydrogen. The objection to this opinion is, that atmospheric air is not found issuing from the coal, and when the coal is opened up by mining, the pyrites is found in its natural state without any marks of decomposition.

That the hydrogen abounds already formed in the coal, is proved by this fact; it frequently happens, when searching for coal by boring, that the instant the boring-iron perforated the coal, the gas came off in great quantity, and continued to do so for a long period. These issues of gas from a bore-hole, have been ignited, and kept burning for months.

The production of these gases, renders the system of the ventilation of coal mines, a chief point in the system of mining, particularly where the inflammable air abounds, by which the lives of the workmen and the prosperity of the mining concern may be instantly destroyed.

It would require a long dissertation, and the most minute detail, to give a clear view of the almost infinite variety of cases connected with the accumulation of inflammable air in the mines of a colliery, and of the plans and methods which have to be employed and varied for the ventilation, corresponding to each particular situation of the mines, the workings of which may be either upon a very extended, or very limited scale; nothing short of a long tried experience is equal to the task. The safety of the workmen depends in a great degree upon the skill of the mining engineer who conducts the work. A high responsibility is attached to the charge; and there cannot be greater presumption than for any man, however intelligent and active regarding mining concerns, where there is no inflammable air, to undertake the management of a colliery infested with it; unless he has been regularly trained to the business, and has, in the course of that practical education, seen "the service" in all its intricate varieties. We shall endeavour to explain, in a manner as concise as possible, a few of the general plans of ventilation, beginning with the most simple, and going on progressively to the most intricate.

The least dangerous gas, and the most simple to manage by ventilation, is the carbonic acid.

In many instances, the ventilation of such mines, particularly where the depth is not great, is conducted with very little trouble, the practice being to work them with a number of pits sunk in succession. When an engine pit is sunk to the coal in the manner before described, the only difficulty is to convey air to the second pit from the bottom of the engine pit, which is effected in several ways.

If an air-pipe has been carried down the engine pit for ventilation while sinking, additional pipes are connected with the upright pipe, and laid along the pavement, or are attached to one of the corners of the mine next the roof. These pipes are lengthened as the mine proceeds; by which means the air at the forehead is drawn up the pipes, and its place is supplied by atmospheric air, which descends the shaft in a constant equal current, which is regulated by the draught of the furnace at the pit mouth. This operation is continued until the miners cut through upon the second pit, when the air pipes are no longer of any use; for it is a fact well known, that the instant such communication is made, as represened in Plate CCCXCIII. Fig. 6 the air spontaneously descends the engine pit A, and passing through the mine *a*, ascends in a constant current up the second pit B. The air in descending A is of the temperature of the atmosphere, and in winter will freeze water from the top to the bottom of the pit; but its temperature is increased in passing through the mine, and ascends the shaft B at a temperature greatly increased. When pits are of unequal depth, as represented in the Figure, the current of air is very uniform, and in one direction. If the second pit was of the same depth, and the bottom and mouth of each in the same level plane, the air would not remain stagnant, as in an inverted syphon filled with water, but would of its own accord circulate down one pit and up another, not regularly in one direction, but would sometimes circulate the one way and sometimes the other, according to the changes of temperature at the surface, modified by calms and strong winds. There is in coal mines an internal heat, which, from the experiments we have made, varies from the common average temperature of air, and springs of water at the surface of the earth, to a temperature of 77° of Fahrenheit. There are cases, where pits are sunk, and communications made, without a circulation being produced either by pipes or ventilation tubes; and if at any time the air became dull at the forehead, it was invigorated by pouring a few puncheons of water from the pit mouth down the pit. If this was not successful, there is a simple plan of carrying air from the pit bottom to the forehead of the mine, by cutting a ragglin or trumpetting, as it is termed, in the side of the mine, as represented in Plate CCCXCIII. Fig. 7. where A is a mine in the coal, and B the ragglin, which is from 15 to 18 inches square. The coal serves as three sides of an air pipe. The fourth side next the mine, is covered with thin deals made air tight, and nailed to small props of wood fixed betwixt the top and bottom of the lips of the ragglin. This is a mode very generally practised in running mines of communication, and dip-head level mines, where carbonic acid abounds, or when air is liable to become stagnant, and difficult for the support of the light by which the miner works.

When a circulation is not effected by the ragglin or air pipes, which proceed from the volume of fresh air at the bottom of the pit, the air is sometimes impelled through them, by means of ventilating fanners, the tube from which is placed at the pit bottom, and the vanes or leaves of the fanners are impelled with great velocity by means of a wheel and pinion wrought by the hand. In other cases, large bellows, similar to those used by smiths, with a very wide nozzle, are applied in the same manner as the fanners. These methods are only used as a temporary resource, when the mines have not to be carried to any great distance. The circulation thus produced by propelling, in place of educting the air, is very faint, and the pulses feeble. Trials have been made with the bellows, by inverting their common mode of action; that is, by attaching the air pipe to their under valve. By this plan the air is educted, and blown out or discharged at the nozzle. We conceive this plan would be very suitable for sinking shallow pits or wells, where there was no great accumulation of carbonic acid. The application of the ventilating fanners in the same manner, we presume, in many cases would be an improvement, from the great obstacles presented against the propelling of air through pipes, although a very strong force is applied.

Another of the simple methods pursued in ventilating mines which are level free, and where this gas abounds, is to allow a small quantity of water at the pit head, to fall freely down a pipe of a foot or eighteen inches diameter. This water carries down an astonishing quantity of air with it, and the water and air falling into a cistern at the bottom of the pit, the air separates from the water, and is by its accumulation and elasticity propelled along the pipes below ground to the forehead, or is allowed to diffuse itself freely along the mines, and through the workings of the pit.

Ventilation is also produced in collieries upon a small scale, by placing a horizontal funnel at the top of air pipes elevated a considerable height above the pit mouth. The funnel turns round upon a pivot, by means of a tail-piece moved by the wind, so as to present the mouth of the funnel always to receive the wind; or a circulation is produced by having fires of coal in iron grates, either at the bottom of an upcast pit, or suspended by a chain some fathoms down; and we have seen on an emergency, when there was a breeze of wind, a ventilation produced by placing an awning of canvas in a perpendicular direction, and in a semicircular form around the lee-side of the pit mouth; the canvas being suspended on temporary uprights of wood.

These are the ordinary methods generally practised in collieries of a moderate depth, where carbonic acid abounds, or where there is an absolute want of air. In such cases the circulation of air through the wastes, and along the wall faces, is very easily managed, and with very little expence the air descending the engine-pit, and ascending one to the rise.

In all coal-mines the circulation of air is regulated, as to its line of direction, by double doors, named main-doors or bearing doors. They act as air-valves, and cut off a current of air, going in one direction, from joining or mixing with a current of air proceeding in another. These doors are placed upon the main roads and passages in the mine, and are of great importance in ventilation. Their mode of operation is represented in Plate CCCXCIII. Fig. 8. where A is the downcast, B the upcast pit, sunk towards the rise of the coal, and C the dip-head level. If in this case the mines were wrought without any attention being paid to the circulation of the air, it would descend the pit A, and proceed in a direcline up the rise-mine to the pit B, where it would ascend; the consequence would be, that all the mines and boards to the dip of the pit A, and lying on each side of the pits, would have no circulation of air, or would be laid dead, as it is termed. To obviate this, double doors are placed in three of the mines adjoining the pit, viz. at *a* and *b*, *c* and *d*, *e* and *f*; all of which open inwards to the pit A. By this arrangement the air being prevented from passing directly from the pit A to the pit B, by the doors *a* and *b*, it would have taken the next and nearest direction by *c*, *d*, and *e*, *f*; but the doors in these mines prevent this, it therefore must proceed downwards to the dip-head level, where it will spread or divide, one portion taking a course to the right, the other to the left. Upon arriving at the boards *g* and *h*, it would naturally have ascended by them; but this is prevented by a building or stopping placed at *g* and *h*. By means of these stoppings placed in the boards next the dip-head level, the air can be carried to the right or left hand for miles, if necessary, providing there is a train or circle of communication of air from the pit A to B. Suppose the boards *i* and *k* are open, the air will ascend them, as shewn by the arrows; and, after being diffused through the workings, will again meet in a body at *a*, and ascend the mine to the pit B, having combined with it the deleterious air which it found in its passage. Without double doors on each main passage, the regular circulation of the air would be constantly interrupted and deranged; for example, suppose the door *c* removed, and only *d* remaining in the left-hand mine, all the other doors remaining as they are, it is evident that the instant the door *d* is opened, the air finding a more direct passage in that direction, would ascend by the nearest course *l*, to the pit B, and lay dead all the other parts of the work, there being no longer any circulation. As the passages upon which the doors are placed are the chief roads by which the workmen pass and re-pass to their work; and as the corves are also constantly passing from morning to night, a single door, such as *d*, would be so often shut and opened, that the ventilation would be rendered very languid. The double doors completely correct this fault; for when men, or horses with loaded corves, are proceeding to the pit bottom A, the door *d* is opened, and as soon as they pass, it is shut, so that they are in quiet or still air, contained betwixt the doors *d* and *c*, as *c* prevented the air from changing its course while *d* was open; when *d* is thus shut, the door *c* is opened, when the men and horses pass on to the pit bottom at A, the door *d* preventing any change in the circulation; while the door *c* is open; the men and horses, in returning from the pit, observe the same rule, first opening the door next them, then shutting it before they open and pass the other. By understanding this mode of separating and disjoining air courses from each other, the continuance of this separation in a working of any extent, will be easily comprehended. When carbonic acid abounds, or when the carburretted hydrogen is in very small quantity, the air is conducted from the pit to the dip-head level, and, by placing stoppings in the off-break of each room next the level, it is carried to any distance along the dip-head levels; and the farthest room on each side being left open, the air is allowed to diffuse itself through the wastes along the wall faces, and to ascend the upcast pit, as represented in Fig. 13. Plate CCCXCI.; but if it should happpen that the air becomes stagnant along the wall faces, stoppings are put up through the workings in such a manner as to direct the main body of fresh air to pass along the wall faces for the workmen, while a partial portion of the air is allowed to pass through the stoppings to prevent any accumulation of bad air in the wastes. In such cases as have been mentioned, the stoppings are made in a very superficial manner, with stones and rubbish, and frequently with rubbish alone, there being no danger from an explosion taking place.

The mode of ventilation thus described is very simple, and the consequences of any inattention or mistake, are generally not of a very alarming nature, nor fatal to the workmen, or very injurious to the interest of the concern. But where the inflammable air abounds, as in many of the districts in England, particularly in the counties of Northumberland, Durham, and Cumberland, a very different field of action is presented to the mining engineer. There a host of difficulties attend him at every step, from the moment he breaks the ground for the fitting, or winning of a colliery, to the day in which the last corve of coals ascends the pit. Water, mud, and quick-sands oppose his progress in passing through the alluvial cover; and in the rock strata, beds of stone yielding vast quantities of water, have to be stopped by cribbing or tubbing, and frequently much inflammable air issues from the cutters of the rock and beds of coal, which has to be attended to and carried off for the safety of the workmen; and no sooner is the coal gained at the pit bottom, which is the great object of all his labours, than an immediate and most careful attention is required, to secure a circulation of air, there being instances where the workmen dare not advance even six feet into the whole wall, or solid coal, without having the circulation of fresh air brought within three feet of the fore head where he works. When this is considered, and when it is known that, in practice, the air is carried for many miles in regular labyrinths, through the wastes, and along the distant and widely-extended wall-faces, where every room requires its ventilation to be attended to; and as upon the correct ventilation the lives of the workmen and prosperity of the mining concern depend, some faint idea may be formed of the important and arduous duty of the mining engineers in these districts, and of the severe application of mind, and laborious toil they incessantly undergo, and patiently endure.

The chief and general plan practised by these engineers, in those very deep and extensive collieries, to produce circulation, is by means of rarifying the air at the upcast shaft, by a very large furnace placed either at the top or bottom of that shaft. The latter is the best, and generally preferred.

Another method is by exhaustion, effected by an immense air pump, wrought by machinery; and, in extreme cases, the cascade, or water-fall, is resorted to.

When the furnace is placed at the top of a pit, it is constructed according to what is represented in Fig. 3. Plate CCCXCI. When it is placed upon a single pit, or upon one of the divisions of a pit, the pit which is thus to be the upcast is made air tight at top, by placing strong buntons, or beams across it, at any convenient distance from the mouth; upon which buntons a close scaffolding of plank is laid, and, for farther securing its being air tight, it is moated over with well-wrought plastic clay. At a little distance below the scaffold, a passage is previously cut, either in a sloping direction, to connect the current of air with the furnace, or it is run horizontally, and communicates with the furnace by a perpendicular opening. If there be any obstacle to the placing of the scaffold down in the pit, the pit can be made air-tight at top, and an air tube of brick carried along the surface to the furnace. These furnaces are made of a size corresponding to the extent of ventilation to be carried on, and the chimneys are constructed either round or square, from 50 to 100 feet in height, having an inside diameter of from 5 to 9 feet at bottom, and tapering to 2 feet 6 inches or to 3 feet diameter at the top, proportioned to the height and diameter at bottom. These chimneys, having so great a taper, require only to be 9 inches thick, or one brick in length, excepting a lining at the bottom of fire brick, where the heat of the furnace acts with force.

Although these furnaces placed at the surface are still used, yet they are in a great degree superseded by the more effectual plan of placing a furnace at the bottom of the pit, which is much more effectual than the former, for this reason, that the shaft through which the air ascends to the furnace at the top of the pit, is always at the ordinary temperature; from which cause, the instant the furnace is not attended to, and allowed to grow languid, the circulation of air through the mines grows languid in a corresponding degree, and consequently dangerous, whereas, when the furnace is placed at the bottom of the pit, the shaft is heated through its whole length; the consequence of which is, that although the furnace should be neglected, and grow languid, and although the fire in it be quite extinguished for a considerable time, the circulation will continue to be good, as the air in the upcast pit is rarified by the heat remaining in the shaft walls. When furnaces were first placed at the bottom of the pits, or at a little distance under the roof of the coal, the smoke which proceeded from them, and the air highly heated, rendered it impossible for the onsetters to work there. The consequence of which was, the pit in this case was of no use for drawing coals. Of late, this fault has been obviated, by adopting an improved plan, as represented, Fig. 9. Plate CCCXCIII. where *a* is the lower part of the upcast shaft; *b* the furnace built of brick, arched at top, and the sides insulated or built clear of the solid coal in which it is placed. Betwixt the sides of the furnace wall and the coal, a small current of air constantly passes to the shaft, to prevent the coal taking fire. The furnace is wide, and open in front, that the air may have a free passage over the burning coals; and the coals burn upon furnace bars, having an ash pit below them similar to the construction of furnaces used for engine boilers. The furnace is placed at any convenient distance from the pit bottom, such as forty yards. From the end of the furnace a mine is cut in a rising direction at *c*, and communicates with the shaft at *d*, at the distance of from 6 to 10 fathoms from the bottom of the pit. By this excellent arrangement, the furnace and furnace-keeper are completely disjointed from the pit. The pit bottom is not only free from all incumbrances, but is cool and temperate; and the shaft is at the same time as serviceable as any other for the drawing of coals. As the heated and vitiated air, with the smoke, are not only very unpleasant and troublesome to the banksmen, who work close to the pit mouth; but as much machinery is so frequently employed at a Newcastle pit having three or four divisions, with frequently one or two large water-drawing engines, with two coal-drawing engines, these, closely grouped together around a narrow pit mouth, not only greatly obstruct the ascending and descending currents of air, but the force of high winds has often had the effect of beating down the ascending current of air, and throwing the whole circulation below ground into a languid, dead, and dangerous state. To obviate this, the following plans have been successfully adopted, as shewn in Fig. 10, which represents the top of a Newcastle coal pit. *a* the upcast shaft, with the furnace at bottom; *b* the downcast shaft, by which the fresh atmospheric air descends; *d* the brattice carried above the pit mouth. At a little distance below the settle boards, a mine *c* is carried to communicate with the surface from the downcast shaft, over which a brick tube or chimney is built from 60 to 80 feet high, from 6 to 8 feet diameter at bottom, and from 3 to 5 feet diameter at top. Upon the top of this chimney a funnel, made of deal, is placed in a horizontal direction, which turns easily round, being hung upon a pivot. The vane *f*, made also of deal, keeps the mouth always opposite to the direction of the wind. An arrangement, exactly similar in every respect, is made at the upcast shaft *a*, with this difference, that the funnel is constructed to turn its mouth in the direction of the wind. From an inspection of the Figure, the effect of this arrangement will be seen, so that a high wind rather aids than injures the ventilation.

The principle of ventilation being thus obtained, the next plan in opening up a colliery, and in driving all advance mines whatever, is the *double mine*, or *double headways course*, upon the simple yet very ingenious principles of which, the circulation of air and ventilation depend at the opening of a colliery.

The double headways course is represented in Plate CCCXCIII. Fig. 11. where *a* is the one heading or mine, and *b* the other. The heading *a* is immediately connected with the upcast side of the pit *c*, and the heading *b* is connected with the downcast side of the pit *d*. The pit is rendered completely air-tight by the division made of deals from top to bottom, named a brattice wall, so that no air can pass through the brattice from *d* to *c*. and the communication betwixt the two currents of air is completely cut off by a stopping betwixt the pit bottom and the end of the first pillar; the pillar or walls of coal, marked *e*, are named stenting walls; and the openings betwixt them are named walls, or thirlings, the arrows show the direction of the air. The headings *a* and *b* are generally made about 9 feet in width, the stenting walls 6 or 8 yards in thickness, and holed or thirled at such a distance as is found most suitable for the state in which the air is. The width of the thirlings is 5 feet. When the headings are set off from the pit bottom, an opening is left in the brattice at the end of the pillar next the pit, through which the circulation betwixt the upcast and downcast pits is carried on; but as soon as the workmen cut through the first thirling, No. 1, the opening in the brattice at the pit bottom is shut, by which means the air is instantly drawn by the power of the upcast shaft through that thirling, as represented by the dotted arrow: this evidently brings a direct stream of fresh air close to the forehead where the workmen are. They then proceed with the two headings *a* and *b*; and as soon as they cut through the thirling No. 2, a wall of brick and lime, four and a half inches thick, is built across the thirling No. 1, which building is named a stopping; this, being air-tight, forces the whole circulation through the thirling No. 2. In this manner the air is carried forward, and circulated always by the last made thirling nearest the forehead, care being taken the instant a new thirling is made, that the last thirling through which the air was circulating be secured with an air-tight stopping. In the figure, the stoppings are placed in the thirlings No. 1, 2, 3, 4, 5, 6, and consequently the whole circulation passes through the thirling No. 7, which is the nearest to the foreheads of the headings *a*, *b*. From an inspection of this figure it is evident, that by this very simple plan a circulation of air may be carried to any distance, and in any direction, however various; for instance, if, while the double headways course *a b* is going forward, other double headways courses are required to be carried on at the same time on both sides of the first headway, the same general principles have only to be attended to, as shewn in Fig. 12. where *a* is the upcast, and *b* the downcast pit. The air proceeds along the heading *c*, but is prevented from proceeding farther in that direction than the pillar *d*, where it is obstructed by the double doors at *e*, it therefore proceeds in the direction of the arrows to the foreheads at *f*, and passing through the last thirling made there, returns to the opposite side of the double doors, then ascends the heading *g* to the foreheads at *h*, passes through the last made thirling there, and descends the heading *i*, until it is interrupted by the double doors at *k*, the air then passes along the heading *l* to the foreheads at *m*, returns by the last made thirling there, along the heading *n*, and lastly descends the heading *o*, and ascends the upcast pit *a*, mixed with all the impurities which it met with during its circulation: this figure or diagram is an epitome of the mode by which collieries of the greatest extent are wrought. The air courses in some are from 30 to 40 miles in length, so that when the circulation of air is conducted by means of a pit divided by a brattice wall only a few inches thick, the air which is descending the downcast on one side of the brattice, at six o'clock in the morning, has to circulate through a course of perhaps 35 miles, and at six o'clock at night is only ascending by the other side of the brattice, a division only about seven inches in thickness. From this description of the system of ventilation of coal mines, it is evident that the furnaces which are the immediate cause of the circulation, require to be most particularly attended to, and kept in constant regular action night and day, and from year to year, during the existence of the colliery; any inattention to this duty, stagnates the circulation, and places in extreme hazard the lives of the workmen and the welfare of the colliery. Upon considering the principles explained in these figures, it is evident, that if any number of boards are set off from any side of these mines, either in a level, dip, or rise direction, the circulation may be extended to each forehead, upon the principle of an ingoing current to each, and a returning current from the same.

It requires particularly to be noticed, that although the circulation of fresh air is thus carried forward to the last made thirling next the foreheads *f*, *h*, and *m*, Fig. 12. and circulates through the thirling which is nearest to the face of every board and room, the discharge of inflammable air is frequently so great from the solid coal, that the miners dare not proceed onwards above a few feet from the current of fresh air, without the danger of being burnt from the gas igniting at their candles. To secure against this accident, temporary shifting brattices are used. They are made of deal about three quarters of an inch thick, from three to four feet broad, and about ten feet long, with cross bars for binding the deals together, and a few finger loops cut through them for the more expeditiously lifting and placing them in exact position. Every colliery, where inflammable air abounds, has a number of those brattices ready for service, and a great store of brattice deals for emergencies, when an explosion unfortunately takes place.

The manner of applying the temporary brattices is represented in Fig. 13. where the air circulates freely through the thirling *a* before the brattices are placed. *b* and *c* are two headings, boards, or rooms, which are so full of inflammable air as to be unworkable. Props are placed near the upper end of the pillar *c*, betwixt the roof and pavement, and about two feet clear of the sides of the next pillar, so that the miner can pass along betwixt the pillar side and the brattice. The brattices are then fixed with nails to the props, and while the lower edge of the one brattice rests on the pavement, the upper edge of the upper brattice is in contact with the roof, by which means any variation of the height in the bed of coal is compensated by the overlap of the brattices; and as the boards advance, shifting brattices are laid close to and along side of the first set. The miner sets additional props in the same parallel line with the former, and slides the brattices forward, in order that the air may circulate close to the forehead where he is at work, the distance betwixt the brattice and the forehead being regulated by the issue of inflammable gas and the velocity of the circulation of the air—*d d* are the props, and *f* the brattices. By this arrangement the air is prevented from passing directly through the thirling *a*, and is forced along the right-hand side of the brattice, and sweeping the wall-face, or forehead, returns by the back of the brattice, then passes through the thirling *a*; but is prevented from returning in its former direction by the brattice placed in the forehead *c*, by which it ascends, and makes the return close to that forehead. In this manner headways and boards are ventilated, until another thirling is made at the upper part of the pillar, when the thirling *a* is closed by a brick stopping, and the brattices removed and carried forward for a similar operation.

If a blind pit or stapple has to be sunk from one coal to another, or to regain a coal upon the other side of a slip, the ingoing current of air must be carried to the side of the pit, and conducted down one side of a brattice, which is lengthened progressively as the pit grows deeper, and the circulation or return air passes up the other side of the pit, by which the rubbish is drawn up, the brattice is carried down close to the pavement, after which the coal is opened up with double headways courses in the manner as before described.

Sometimes pits have to be mined upwards, in which case the inflammable air, from its specific lightness, keeps always about the heads of the workmen. The circulation is produced in this case by a brattice carried up the shaft to produce a current of ingoing and returning air, exactly the inverse of the above.

When blowers occur in the roof, and force down the strata, so as to produce a large vaulted cavity, it is necessary to sweep away the accumulated gas, which would not only lodge in the cavity, but would descend in an undiluted state under the common roof of the coal. The mode of doing this is represented, (Plate CCCXCIII.

Fig. 14. where *a* is the bed of coal, *b* the blower, *c* the cavity formed by the falling of the roof strata, *d* is a passing door, and *e* the brattice; by this plan the current of air is carried close to the roof, and constantly sweeps away and dilutes the inflammable air of the blower as fast as it issues. The arrows show the direction of the current; were it not for this direction of the ventilation, the accumulated gas would mix with the current of common air, and produce an explodeable mixture. The gas issuing from blowers is sometimes conducted in pipes into other air courses, where the air is returning to the upcast shaft, which prevents it troubling the miners, by contaminating the ingoing air.

There is another plan in the system of ventilation, which is, the crossing of air-courses, that is, when in the progress of ventilating a colliery, one air-course is brought forward at right angles to another, and has to pass it, in order to produce ventilation in works upon the other side. This is effected in the manner represented in Fig. 15. where *a* is a main road with an air-course, over which the other air-course *b* is to pass. The sides of the air-course is built with bricks, arched over and made air-tight, and a mine is driven in the roof strata, as represented in the Figure. In some cases, the roof of the air-course *a* is laid over with plank made air-tight; by this method, air-courses can be made to cross and recross each other with great facility. It has been found, from the practice of the most eminent engineers, that these air-courses, thus contracted, should be in general six feet, or at least five feet on the side, that is, the area to be 36, or at least 25 square feet, and that the general velocity of the current of air through the works should be from three to four feet per second, or about 2½ miles per hour.

Another method has also been brought forward for rarefying the air in the upcast shaft, by means of steam produced from a large boiler, such as is used for steam engines. The steam from the boiler is conducted in deal tubes, in preference to iron pipes, on account of deal being a very slow conductor of heat; these pipes are carried at least half way down the pit, and the intention is, that the steam be made to issue from the lower end of the tube as hot as possible. The steam, immediately on coming in contact with the air, is condensed. The caloric or latent heat is disengaged, heats the air in the shaft, and produces a constant ascending current, while the condensed steam falls in a shower to the pit bottom. This mode of producing an ascending current of air has not the energy of the common furnace; and although it allows the upcast shaft to be used as a pit for drawing coals, the dropping of the condensed steam keeps the shaft walls wet, which is not only uncomfortable, but in some degree counteracts the power of the rarefying process.

It has frequently been suggested by men of science, and by mining engineers, that ventilation might be produced, both strong and effective, by propelling a current of air down a shaft by means of large iron cylinder bellows wrought by powerful machinery. From every experiment yet made, this appears to be the least effective of all the plans of ventilation.

It is well known, that when the least advance is made towards forming a vacuum, the remaining part of the air, instantly acting by its great elasticity, produces an equilibrium through the mass of air. It is this principle, brought into constant action by means of heat applied to the ascending current of air, that the before-mentioned systems of ventilation act.

An exhausting machine, which may be termed a Hydraulic Air Pump, has been applied to the ventilation of mines of a moderate extent, and where there was no dangerous quantity of inflammable air. It is the invention Mr. John Taylor of Tavistock, in the county of Devon, and has been applied with complete success. The construction is very simple, has very little friction, and shows the ingenuity of the inventor. It is represented in Fig. 1. Plate CCCXCIV. where *a* is a large cistern, nearly filled with water, made of wooden staves, hooped with iron, circular, and from six to eight feet in depth. Through the bottom of this vessel a pipe *b* passes from the mine to be ventilated, and passing up through the water, is carried about a foot above it. Upon the top of this pipe is an air-tight valve, opening upwards. Over this pipe, and within the sides of the cistern, a cylinder of plate iron is placed, open at the bottom, but close at the top, in which top an air-tight valve is placed, also opening upwards. This iron cylinder is made to move in a vertical direction, by guides or sliders, and its upper end is attached to a lever, which is moved, either by a water-wheel or a steam engine. When the cylinder descends, the value *c* at the top of the pipe shuts, and the air contained in the cylinder opens the valve *d* in the cylinder top, and escapes, but the instant the cylinder ascends the valve *d* shuts, and the valve *c* opens, by which means a quantity of air, equal to the contents of the cylinder above the surface of the water, is drawn from the mine through the pipe *b*. This repeated exhaustion causes a regular circulation of air through the mine, to supply the circulating current produced by the working of the machine. An exhausting machine of this construction may be made, from the smallest size to be wrought by the hand, to any requisite size to be moved by machinery.

These are the general plans which have been put in practice for the ventilation of collieries with success.

The ventilation of coal-mines, where inflammable air abounded, was conducted on the old principle of ventilating only the foreheads and wall-faces, where the men were at work, until the year 1760. The consequence of which was, that the process being irregular and uncertain in its operation, the accidents from explosions were frequent and fatal. To obviate these misfortunes, the ingenious Mr. Charles Spedding, a native of Cumberland, contrived and brought into practice the present system of ventilation, that is, he converted each room, board, or mine, as soon as it was formed, into an air-course; by which means, he not only ventilated the wall-faces where the miners wrought, but also the whole extent of the old wastes. This was a very great and important improvement, and the mining interests of Great Britain have been highly benefited by it. To the memory of Mr. Spedding every tribute of respect is due.

The general system, as to the distribution of the air, after passing down the downcast shaft, is to give the first of it to the stables where the horses are kept, then to the workmen in the foreheads, when the air, loaded with what mixtures it may have received, traverses the old wastes; and, lastly, passing over the furnace with all the inflammable air found in its course, ascends the upcast shaft, and is dissipated in the common air.

Mr. Spedding's system is termed, "coursing the air;"

and, according to the abundance of the inflammable air in the mines, the coursing is either conducted up one room, and returned by the next alternately, through the whole extent of the works; or two or three rooms are connected, so that the air passes up two or three rooms, and returns by the same number alternately, as above mentioned.

The most ingenious system has been greatly improved by the mining engineers of the Newcastle and Whitehaven districts collectively; and, in particular, by Mr. Buddle before mentioned, who, in his report upon the ventilation of coal-mines, has shown, in a very clear and explicit manner, the result of an extensive practice, the manner of applying the system effectually, and of guarding those points when the greatest danger is likely to arise. Several of the following remarks and examples are taken from that report.

The improved system of ventilation upon an extended scale, by which the current of air sweeps every corner of the workings, is represented, Fig. 2. Plate CCCXCIV. where *a* is the downcast, and *b* the upcast shaft. By following the course of the arrows, it will be seen, that the air passes first along the two rooms *c*, *d*, having free access to each through the walls, but is prevented from entering into the adjoining rooms by the stoppings which form the air-courses: it sweeps the wall faces of the rooms *c*, *d*, and makes a return down the rooms *e*, *f*, but is prevented from proceeding farther in that direction, by the stoppings *g*, *h*; it proceeds to the foreheads *i*, *k*, and single courses all the rooms to the foreheads *l*, *m*; at this point it would go directly to the upcast pit *b*, if it were not prevented by the stopping *n*, this throws it again into double coursing the rooms, until it arrives at *o*, when it goes direct to the furnace, and ascends the shaft *b*. The lines across each other, represent the passing doors; and these may be substituted in any place for a passage where there is a stopping. The stopping *p*, near the bottom of the downcast shaft, is termed a main stopping, because, if it was removed, the whole circulation would instantly cease, and the air, in place of traversing in the direction of the arrows, would go directly from the downcast pit *a*, to the upcast pit *b*, along the mine *q*. The consequence of which would be, every mine and room of the workings would be laid *dead*, as it is termed, and be instantly filled with inflammable air, which, if not guarded against, would either fire at the miner's candles, or at the furnace next the upcast pit *b*. In the same manner, a partial stagnation in a district of the colliery, would be produced by any of the common stoppings being removed or destroyed by accident, as the air will in that case always take the nearest course to the upcast pit. Main stoppings are made very secure by strong additional buildings of stone, and they are made at different places, to keep the main air-courses entire, in the event of an explosion,—by means of these many lives have been saved. This system may be extended almost to any distance from the pit bottoms, provided the quantity of fresh air which is circulating can sufficiently dilute the inflammable air which issues from the mines, and keep it under the firing point. In this manner, the air ventilates first one pannel of work, and then others in succession, the air passing from one pannel to another through the barrier or pannel walls, by means of mines, as in Fig. 1. Plate CCCXCII. and may either be single, double, or triple coursing, according to the quantity of gas in the mine.

If several coals are wrought in the same shaft, the ventilation is first completed in one coal, and from thence is carried by means of stapples or blind pits from one coal to another, it always being the study of the mining engineer to give the first of the air to the working foreheads, and that it latterly traverses the old wastes. When, however, the flow of inflammable air is too great, separate ventilations are made for each coal.

In ventilating the very thick coal in Staffordshire, though there is much inflammable air, less care and attention are required than in the north of England collieries, the workings being very roomy, and the air-courses of comparatively small extent. The air is conducted down one pit, carried along the main roads, and distributed into the sides of work, as represented in Plate CCCXCIII. A narrow mine, named the air-head, is carried in the upper part of the coal in the rib walls along one or more of the sides. In this instance it is carried all around, and the air enters at the bolt hole *e*. Lateral openings, named spouts, are made from the air-head mine into the side of work, and the circulating current mixed with the gas in the workings enters by the spouts, as represented by the arrows, and returns by the air-head at *g* to the upcast pit.

When blowers are met with in the first of the air, by which all the gas which issues from a blower is carried along the wall-faces where the men are working, so as to render their situation very dangerous, it is necessary to reverse the course of the air, in order that the issue of gas from the blower shall be diluted by the last of the air, and carried directly to the upcast shaft. This is effected by applying the general principles before laid down, and by removing the stoppings in one place of the air-course, placing others in a counteracting direction, and causing the one current of air to cross the other by an arch, as before mentioned. Sometimes these operations have to be performed at places at a great distance from each other. When this is the case, and the engineer has, from the plan of the colliery, laid down with precision the line of operation to be pursued, the men are divided into parties, each having a person of skill at their head. Their watches are set to one time, and at an appointed minute one set of stoppings is quickly driven down and new ones built up, which have the effect of reversing the current of air without laying any part of the works dead.

When at any time the gas comes off suddenly, and the air becomes foul at the foreheads, ready to explode, if no immediate remedy is found to be effectual, the working of the coal is suspended, and a flow of air is allowed to pass directly from the fresh in-going current, so as to mix with and dilute the air highly charged with gas, before it comes in contact with the furnace. This is termed *skailing the air*, otherwise the gas would ignite at the furnace, and go back like a train of gunpowder through the whole extent of the workings, carrying destruction and devastation in every point of its progress. By skailing the air, time is given for going forward with water, and drowning the furnace, so as to insure safety, until plans are adopted for rendering the ventilation safe. When the furnace is extinguished, and the inflammable air continues to fill the works, the only effectual remedy is the cascade, which is produced by working the steam-engine, which draws the water from the mines, and allowing the whole of the water to fall down the pit, which has such power in a descent of 600 feet in carrying air with it, that it forces a sufficient current through every part of the work. By these means the ventilation is corrected, and again put into its usual train.

In collieries which have been wrought for a considerable time, particularly where there are goaves, creeps, or crushed wastes, the inflammable air is much influenced by the state of the atmosphere. In the above case, when the barometer is low, or about 29°, the gas issues from every crevice of the old works, and incommodes and endangers the miners very much. For this reason, the state of the barometer is examined every morning.

It would require volumes to describe the infinite variety of circumstances connected with the system of ventilation. Where inflammable air abounds, they vary with the state of the atmosphere, the abundance of the gas, and, in a great degree, with the length which the air traverses. All that can be stated here are general principles.

In the manner now described, the ventilation of collieries has been carried on progressively to an astonishing extent from the year 1760, (when Mr. Spedding's important improvement in ventilation was brought forward,) to the year 1815; betwixt these periods, notwithstanding the well ordered regularity and complete system which had been introduced in coal mining, by the mining engineers of Northumberland, Durham, and Cumberland, and also notwithstanding their very active and unwearied attention, living out of the world, and devoted to the hazardous duties of their station, yet, independently of these circumstances, explosions frequently, nay, almost daily, took place, and catastrophes, the most melancholy which have occurred in civil life, were the consequences. Year after year passed away, and every year added greatly to the list of victims carried away by this fatal pestilence. Being in its nature subtle and invisible, and when at the point of ignition still capable of supporting animal life, and flame, it lurks like an assassin, and strikes deadly when least suspected. The elegant and figurative language of the Sacred Scriptures may be most aptly applied to it, as "The pestilence which walketh in darkness, and destruction which wasteth at noon day."

To describe the catastrophe attending an explosion of an extensive coal-mine, would require the pen of an able writer, guided by one who has been present at such a scene; but some faint idea may be formed from the following description.—We shall suppose a mine of great depth, perhaps from 100 to 150 fathoms, with the workings extended to a great distance, the machinery complete in all its parts, the mining operations under a regular and rigid discipline, with rail-ways in every direction; the stoppings, passing doors, brattices, and the whole economy of the mine so arranged, that every part of the work is performed like a well regulated machine. To see a mine of this extent at full work is a scene of spirited animation, and of wonderful industry; the "sound of the hammer" is heard in every quarter, and the numerous carriages, loaded and unloaded, passing to and from the wall-faces to the pit bottom, are seen driving and thundering along in every direction. At each door, a little boy, named a trapper, is placed to open and shut it. Every one is at his post; added to which, there is a degree of cheerfulness pervading the whole scene, which could scarcely be expected in a place of so sombre an aspect. While the work is thus going forward, it has but too frequently happened, that, from some unforeseen cause, part of the ventilation has become stagnant, or laid dead, as it is termed, by which a great body of inflammable air is gathered into one place, or the sudden opening of a blower has produced the same effect, the certain consequence of which is, that the unsuspecting miner enters it with his candle; ignition takes place; "sudden as the spark from smitten steel," the whole extent of the mine in that direction becomes one blaze of light and flame from roof to pavement, in which the miners are enveloped. It hangs for a few seconds; then from the evolution of immense volumes of gases, with much heat, this pestilence begins to move with the violence of a tornado, and with the noise of thunder, directing its course always in the nearest direction to the upcast shaft. Its power is awful and irresistible. Whatever obstructs its course is swept onward like smoke before the wind. The stoppings are burst, the doors are shivered to a thousand pieces; while the unfortunate miners and boys who are within its range, with the horses, carriages, corves, and coals, are swept along with inconceivable velocity; and when a pillar obstructs the direct course of the current, they are dashed against it, and there lie mingled in one common mass of ruin, desolation and death, as if they had been blown from an immense mortar against a wall! Others are carried direct to the shaft, and are either buried there amidst the wreck, or are blown up and over the pit mouth: So powerful is the blast, that even in the shaft it frequently tears the brattice walls to pieces, blows the corves, which are hanging in the shaft, as high into the air as the ropes will allow them; and not unfrequently the ponderous pulley wheels are blown off the pit-head frame, and carried to a considerable distance in the midst of a thick cloud of coals and coal-dust brought from the mine by the volcanic eruption, which absolutely shakes the solid mass of earth that confines it. The dust rises to a great height, and sometimes obscures the light of the sun in the vicinity of the pit. No sooner is this part of the catastrophe over, and an awful silence produced, than the *back draught* commences, by the descent of air down the shaft to replace the air of the mine as it cools. Every part of the mine is filled with the most deleterious airs, particularly azote and carbonic acid, the result of combustion. Those miners, who were in the direct line of the explosion, have their fate quickly sealed. Others who are not in the direct current are dreadfully burnt. But though the greater number of the miners are at a distance from either of these calamities, yet their fate is perhaps the most severe. They hear the explosion; they know well the certain consequences of it; every one thinks of his personal safety; and the great object is to reach the pit bottom. All the lights are generally extinguished, and they have to pursue their dreary path in awful darkness,—a darkness rendered terrible by the combination of uncommon circumstances. Some of them have been known to make most providential escapes, after clambering over fallen roofs, and the wreck where their fellow workmen lay entombed; but others, deviating from the direct course in the confusion of the scene, wander anxiously onward, dreading every moment to meet the returning pestilential air. At last they feel its power, and knowing the certainty of their fate, they cease to struggle with what is irresistible; they resign their hopes; fall down in a reclining posture; nature is soon exhausted, and they sink in death as if asleep! Such is the fate of the hardy and industrious miners, who venture their lives every day for the comfort of others: and such, frequently, is the misfortune, which, in a moment, comes, like a whirlwind, upon the best arranged mining concerns, after the most laborious exertions, and the most unremitting anxious concern of the mining engineers. The labours and plans of years are in an instant destroyed.

Sad and melancholy as the scene described is, perhaps it is the least part of the melancholy picture. From the general arrangements of collieries, it is found a matter of economy and conveniency to have the workmen's houses, where their families reside, near to the pits. The consequence of this is, that the instant an explosion takes place, the alarm is general, and the wives and relations of those who are in the mine rush to the pit-mouth in a state of distraction, where a heart-rending scene takes place,—a scene which may be imagined, but cannot be described. All the violent effects of sudden grief are the consequence. They look to the horrible pit where those who are most dear to them are entombed, and who but a few hours ago had left them in health and vigour, with the hope of returning happy to their homes.

In such a case the mining engineers have a severe and an imperious duty to perform. The pit, where they must descend, is either rendered dangerous by the wreck of loose timber torn away by the irruption, or the air is in a pestilential state; and, what is still more alarming, part of the coal may have taken fire from the explosion, or a blower may be ignited; either of which would produce repeated and violent explosions the instant the gas accumulated to that point so as to come in contact with the fire. Such a case is not unfrequent, and against this no human skill can guard. This fearful case, with the others before mentioned, is probably combined. All these have to be encountered by the engineer and his assistants. The hope of saving some of the workmen from death, and the ardent entreaties of the agonized relations, place the consideration of personal safety out of the question.

On descending to the bottom of the pit, it is perhaps with great difficulty the mine can be entered, owing to the wreck; if the descending current of air is good, part of the wreck is cleared away. The engineer then considers what are the best immediate plans to pursue, arising from his experience, and an accurate knowledge, not only of the general situation of the workings, but of the direct lines of the air-courses, so that he may in the shortest time restore the ventilation, and, if possible, relieve the miners who may yet be alive. Having formed his plans, he states them to his assistants, and hears any improvements they may suggest; a great quantity of prop-wood and brattice deals are sent down, and they enter the mine as far as the air will allow them; care being taken to have it with them every step as they proceed, and in particular before leaving the shaft, they see that the brattice of it is air-tight; for if any openings are in it, the air would pass directly through it and ascend to the bank.

As the violence of the explosion destroys many of the stoppings, and almost every door upon the air-courses, the whole circulation is laid dead, and the fresh air will of course take the most direct course through the first opening to the upcast shaft. All these must be replaced as they proceed forward with the air; and this work being in general executed with astonishing quickness, many lives are frequently saved.

As soon as the ventilation is restored by these temporary brattices, the stoppings and doors are replaced in a substantial manner, and the workings are resumed with all their former vigour and activity, as if no misfortune had ever happened. From what is stated, and from an inspection of Fig. 2 Plate CCCXCIV. it is evident, that the stability of the main stopping *h*, is an important point, on which account it is counterforted by strong walls of stone; and if stones are easily procured in the mine, it is of great service to counterfort as many of the stoppings as can conveniently be done, so as to resist the explosive force of the fire, and give a greater facility in recovering the ventilation in the promptest manner. The oversmen and deputies who are employed in this service shew a wonderful dexterity in placing temporary brattices. They will work in the dark, with the wreck of one destruction around them, and threatened every moment to be overwhelmed in another, in which the hope of saving a fellow-workman from death gives the most lively energy to their actions; and if they think that a bold effort will save life, they will rush without fear into the midst of pestilential air, and grapple with death. The mining engineers are always at the head of this service, and as they, with their assistants, frequently push forward in the dark, they are exposed to the deleterious effects of the gases, and it is no uncommon thing for those who take the lead, to drop down lifeless, while those who are in the rear seize them by the feet and draw them back into better air, yet no sooner are they re-animated, than the same generous impulse acts in its full force, and they make the same attempt again and again, till nature is exhausted. We need scarcely add, that many fall a sacrifice to the ardour of their generous exertions.

When it is ascertained that fire exists in the wastes, either by the burning of the small dusty coal which lies along the roads, or that the solid coal is on fire, from the ignition of a blower, the descent into the mine is rendered tenfold more hazardous, as a moment's safety cannot be depended on; for if the discharge of gas is great, it rapidly accumulates, and the instant it reaches the place where the fire is, an explosion again takes place, and that repeatedly as long as the causes exist. There have been instances of this kind where the most violent explosions have taken place, regularly within the space of an hour, and continuing to do so for thirty-six hours, each irruption vomiting out of the pit mouth like a volcano. In such cases, no man dare attempt to go down, as his destruction would be inevitable. As the case is desperate, desperate remedies must be applied, which are, either to moat up all the pits and exclude the air, or if this is not practicable, the colliery must be laid in and drowned, by allowing the water below ground to accumulate; and to aid the common growth, the tubbing in the shaft is tapped, and all the body of water from that quarter sent down: when the fire is extinguished, the colliery is refitted in the usual manner.

When fire exists in the waste, with less apparent hazard of life, the mining engineers, with their assistants, descend with portable fire-extinguishing engines. These are placed as near the burning matter as possible, and by playing upon it, the fire is speedily extinguished. It frequently happens, however, that although they see the fire before them, the state of the air prevents them from approaching near enough to allow the engines to play with effect. To remedy this, Mr. Buddle, with that ingenuity for which he is so conspicuous, conceived, that the concussion of air which is produced by the discharge of artillery, might be effective in extinguishing fire, which could not be approached with the engines. He accordingly had small cannons made, and by charging them with powder only, and approaching as near the fire as possible, he has succeeded in blowing out flame by repeatedly firing them. This principle has been proposed lately for extinguishing houses which are on fire.

Such is an outline of the misfortunes incident to coal-mines, and to the engineers and workmen employed where inflammable air abounds.

In the manner before described, and with daily misfortunes of a lesser or greater degree, were the collieries of Great Britain carried on, every one struggling against the direful ravages of the inflammable air; but it baffled the skill of the most experienced engineers, and all the precautions of their most unwearied diligence and anxious attention. The general question, and anxious inquiries were, Can no remedy be devised to avert these awful calamities, to deliver an industrious class of society from such desolating catastrophes? Many plans were proposed, but they were altogether inapplicable. The first person who stepped forward, a number of years ago, and wrote upon the subject, was Dr. Trotter of Newcastle. He published a pamphlet, wherein he proposed to neutralize the carburetted hydrogen as soon as it appeared in the mine, by chemical agents. Every praise is due to him, for his very humane intentions, and earnest endeavour to remedy an evil so great. But although the principles he brought forward were consonant with sound philosophy, and were practicable upon a small scale, they were totally inapplicable to the extended workings of a coal-mine, where there were excavations of many hundred acres, and where the issue of gas was not only incessant, but in great abundance; hence, the principle was not only inapplicable in a general point of view, but the expense of the neutralizing substances must have been so great, even had the principle been applicable, as to render the plan altogether out of the question. After Dr. Trotter's pamphlet, nothing particular appeared for years upon this important subject, the mining engineers, therefore, applied their whole skill and energies in producing a circulation by the means before mentioned, particularly upon the principles of rarefaction and exhaustion by fire.

In some cases, fish, which in the incipient stage of putrefaction, give a strong phosphoric light, had been tried to give light to the miner in very dangerous cases; and the light produced by the collision of flint and steel was universally employed, when candles could not be used without producing an explosion. The machine for producing this light is named a steel mill, which will be particularly noticed afterwards. Philosophers proposed the various kinds of phosphorus, but these were altogether insufficient for the purpose. When tried in the mines, they only produced a most melancholy light, and rather tended to render the "darkness visible:" In the mean time the mines were extended, and the melancholy catastrophes constantly increased. At last an explosion and catastrophe took place at Felling colliery, near Gateshead, in the county of Durham, about a mile and a half distant from Newcastle, more dreadful and melancholy in their consequences than any which had ever taken place in the collieries of Great Britain. This colliery was working with great vigour, and under a most regular system, both as to the mining operations and ventilation; the latter was effected by a furnace and air-tube placed upon a rise pit on elevated ground, south from the turnpike road leading to Sunderland. The depth of the winning was above 100 fathoms; twenty-five acres of coal had been excavated, and such was the execution of work, that from one pit they were drawing at the rate of 1700 tons of coal weekly. Upon the 25th May, 1812, the night-shift was relieved by the day-shift of miners at eleven o'clock forenoon, one hundred and twenty-one persons were in the mine, and had taken their several places, when, at half-past eleven o'clock, the gas fired, and produced a most tremendous explosion, which alarmed all the neighbouring villages. "The subterraneous fire broke forth with two heavy discharges from the dip-pit, and these were instantly followed by one from the rise-pit. A slight trembling, as from an earthquake, was felt for about half a mile around the colliery, and the noise of the explosion, though dull, was heard at from three to four miles distance. Immense quantities of dust and small coal accompanied these blasts, and rose high into the air, in the form of an inverted cone. The heaviest part of the ejected matter, such as corves, wood, and small coal, fell near the pits, but the dust, borne away by a strong west wind, fell in a continued shower to the distance of a mile and a half from the pit. In the adjoining village of Heworth it caused a darkness like that of early twilight, and covered the roads so thickly, that the foot-steps of passengers were imprinted in it. The heads of both shaft-frames were blown off, their sides set on fire, and their pulleys shattered in pieces. The coal-dust ejected from the rise-pit into the horizontal part of the ventilating tube was about three inches thick, and soon burnt to a cinder; pieces of burning coal driven off the solid stratum of the mine were also blown up this shaft."

Such were the fearful and volcanic effects in the mine and atmosphere; but we have yet to state the result of the melancholy catastrophe as regarding the unfortunate miners. Of the 121 persons in the mine, at the time of the explosion, only 32 were drawn up the pit alive; and of these, three died within a few hours after the accident. Thus were no less than 92 persons killed in an instant by this desolating pestilence. The scene at the pit mouth cannot be described.

The viewer, with his assistants, instantly descended, in the face of the most imminent danger, eager to save, if possible, any of the workmen; but the mine was found to be on fire, and they durst not proceed. In consequence of this fire, another explosion took place, and no alternative was left but to shut up the pits, and extinguish the fire, which was accordingly done. The pits were, after a considerable time, again opened, but it was the 19th day of September before the complete ventilation was restored, and the last of the bodies of those who had perished was found; a period of 117 days from the day on which the accident took place. A minute account of this accident was published by the Rev. John Hodgson, the worthy pastor of Heworth; who, upon this melancholy occasion, attended most assiduously, and performed the most painful duties amongst his suffering people. From his account of the misfortune, the particulars above stated are taken.

This fatal misfortune at Felling roused the minds of every one connected with coal-mines, in order to find, if possible, a remedy for preventing such catastrophes.

It appears that Dr. William Reid Clanny, of Sunderland, who, from his medical profession, had frequently to attend at the neighbouring collieries, when the workmen were hurt by the explosions of the gas, had, in the year 1813 turned his attention to the construction of a lamp which would burn amongst inflammable air, and though an explosion might take place in the lamp, would not communicate flame to the external surrounding air. This he accomplished by means of an air-tight lamp with a glass front, the flame of which was supported by blowing air from a pair of small bellows through a stratum of water in the bottom of the lamp, while the heated air passed through water by a recurved tube at top. By this process, the air within the lamp was completely insulated from the external air; and it appears that this was the first lamp that ever was taken into a body of inflammable air in a coal-mine at the exploding point, without producing an explosion of the surrounding gas. Dr. Clanny made another lamp upon an improved plan, by introducing into it the steam of water produced from a small vessel at the top of the lamp, heated by the flame. For these inventions the Doctor twice received the thanks of "The Society for preventing accidents in Coal-Mines;" and he also received the silver, and afterwards the gold medal from the Society of Arts in London. Although these lamps, invented by Dr. Clanny, were upon philosophical principles, displayed much ingenuity, and were absolutely safety-lamps for mines, yet their construction prevented them from being generally used. Nevertheless, Dr. Clanny deserves every praise for his labours and very zealous exertions in the cause of humanity. It appears that nothing farther was attempted in this important matter, until the accident at Felling colliery, as before noticed, when Sir Humphry Davy, Mr. James Stevenson, engineer, Killingworth colliery, Newcastle, and Dr. John Murray of Edinburgh, brought forward safety-lamps, in the year 1816, each constructed upon different principles. Sir Humphry Davy's lamp was made of fine iron wire gauze, without any glass; that of Mr. Stevenson's was made of a strong glass cylinder, having a metal plate at top, and another at bottom, perforated with very small holes, to permit the air to pass to and from the lamp; and that of Dr. Murray was a glass lamp, or rather lanthorn, to which good atmospheric air was brought by means of a long leather pipe from the air-course. Of these, Dr. Murray's lamp was not applicable but in a very few cases; the lamps of Sir Humphry Davy and Mr. Stevenson were both complete safety-lamps in their principle, and are applied in practice; but that of Sir Humphry Davy is decidedly the best, and is generally used in Great Britain. Having no glass, it is not easily injured, and sufficient light for the miner passes through the wire gauze. To each of these gentlemen the world is highly indebted, and in particular the mining interest of Great Britain, for their individual exertions.

The safety-lamp of Sir Humphry Davy was instantly tried, and approved of by Mr. Buddle, and the principal mining engineers at Newcastle. No one was more zealous to prove its safety, and introduce it into the mines, than the Rev. John Hodgson, of Heworth, before mentioned. He descended the mines, entered amongst the inflammable air, and fully satisfied himself of its absolute safety, in order that he might induce the miners of his parish to use it, half of whom he had seen so lately swept away by the dreadful explosion before narrated.

The invention of this lamp has produced a new era in the coal-mining of Great Britain. The steel mills were very expensive, and in certain cases produced explosions, whereas the safety-lamp can be carried without danger amongst inflammable gas ready to explode; and, although the wire becomes red-hot, an explosion of the gas will take place inside of the lamp, without communicating inflammation to the external gas. While we very much admire the great ingenuity of the highly celebrated inventor, we are not less astonished at the uncommon simplicity of the construction. For farther particulars regarding this important discovery, see the article SAFETY LAMP.

The state and purity of the air in coal-mines, from the earliest time of mining, until the discovery of the safety-lamp, were judged of by the appearance presented by the flame of a candle, and this test must, in many circumstances, be still used. When there is only a want of air, or the air is partially vitiated by a small quantity of carbonic acid, or by the perspiration and breath of the workmen, the candle burns with a very dull flame, the tallow ceases to be melted in the cup formed around the wick, and the flame is gradually extinguished. In this case, the candle may be kept burning, by inclining it less or more towards a horizontal direction, which has the effect of melting the tallow with the edge of the flame. By this method the candle is kept burning, but the waste is great, as sometimes more than the half of the tallow drops to the ground unconsumed; an oil lamp is therefore preferable in such a case, as it will keep burning where a candle would be extinguished. When the carbonic acid abounds, no management will make either the candle or lamp burn. In such a case, the mine is unworkable, and must remain so, till a circulation of good air is brought forward. The candles used by colliers in the mines are generally small, with a very small wick, as these are found to produce a more distinct flame than candles of a large size, with a thick wick. The size generally used is at the rate of 20 in the pound weight; but when inflammable air abounds, they are not thicker than a common black lead pencil, there being from 40 to 60 of them in the pound.

In trying the quality of the air by the flame of a candle, the candle is trimmed by taking off the coal or snuff from the wick, so as to produce a clear, distinct, and steady burning flame. If a candle is thus prepared and looked at in common air, a distinct well defined cone of flame is seen, of a fine sky-blue at the bottom next the wick, and of a bright yellow from thence to the apex of the cone; which cone of flame is vesicular, and not a full body of burning matter, as it appears to the eye. Besides this appearance, there is another surrounding the cone, which the brightness of the flame prevents the eye from discerning. This may be seen by placing one of the hands expanded as a screen betwixt the eyes and the candle, and at the distance of about an inch, so that the least point of the apex of the yellow flame be seen and no more. By this arrangement a top, as the miners term it, will be distinctly observed close to the apex of the yellow flame, from an eighth to a quarter of an inch in length. This top is of a yellowish brown colour, and like a misty haze. This haze is not only seen on the top, but it extends downwards and surrounds the flame fully half way, about a twentieth of an inch in thickness; here it assumes a violet colour, which passes into a beautiful blue at the bottom next the wick. The test of the state of the air in mines, or "trying the candle," as practised by miners, depends entirely upon the appearance this vapour or haze assumes as to shape and colour at the top of the flame. The top has distinct and different appearances when burning in atmospheric air, carbonic acid, azote, or carburetted hydrogen, with many variations and modifications, according to the abundance of any of these gases or their mixtures.

When azote, or carbonic acid gas abounds, the top is frequently an inch or two in length, of a decided brown colour, and the flame shortens and burns dimly. If these gases abound, the flame goes out, and the miners retire. No sudden catastrophe arises from these gases in the ordinary course of working mines; it is the carburetted hydrogen which requires the utmost attention and circumspection.

When inflammable air is supposed to exist in considerable quantity, the miner trims his candle and proceeds with cautious step, holding the candle with the left hand, and screening the flame with the other; as this gas floats in the upper part of the mine next the roof, he holds the candle as low as he can, and, keeping his eye fixed on the *top*, advances. If the gas is in very small quantity, he reaches the forehead without observing any material change upon the top. But, if upon advancing as before mentioned, the top begins to elongate and assume a bluish-grey colour, the miner is instantly on his guard, advances with additional caution; and, if the top begins to spire, he kneels on one knee, and, holding the candle near the pavement, gradually raises it up, and observes the change which takes place on the top as it approaches the roof. If the gas is abundant, the flame elongates into a sharp spire, and also the top. It is in general reckoned dangerous when the top changes from the bluish-grey to a fine blue colour, accompanied with minute luminous points, which pass rapidly upwards through the flame and top. When the symptoms are very evidently dangerous, a sudden movement of the hands or body is liable to produce ignition; the experienced miner, in this case, slowly and cautiously lowers his candle to the pavement, and then, turning round, makes his retreat slowly, or slips up his hand and extinguishes the flame. If the miner ventures too far, and approaches the body of gas at the exploding mixture, the top rapidly elongates, and the flame of the candle rises in a sharp spire, several inches in length, when in an instant the whole surrounding gas is in a blaze, an explosion ensues, and the extent of the destructive ravages depends upon the quantity of the gas.

This "*trying the candle*" requires caution, and great experience, particularly in not advancing too far with strong igniting symptoms upon the flame, where the lives of so many men, and the prosperity of the colliery, are at stake. No precise rule can be laid down which may be universally depended upon; all that can be stated here are general facts. Almost every colliery, after having been wrought for some time, gives a peculiar top to the candle; so that while in one colliery an explosion will take place with a top less than an inch long, in another colliery the top will be two inches long, and the air considerably under the igniting point. These differences depend upon several circumstances. If the gas has not run through a long course of ventilation, and is free from mixtures of air, it will ignite with a very short top; while, on the other hand, the gas which has run through a ventilation of 20 or 30 miles, will bear a long top without the least danger. From this it is evident, that a well-tried experience, and thorough practical knowledge, can be the only guides in these cases.

Formerly, when the air in a colliery was at the exploding point, and no thorough ventilation could be produced, it became necessary to carry forward the colliery by means of other light than that of a lamp or candle. This was effected by the collision of flint and steel, produced by an instrument named a steel mill. It is composed of a small frame of iron with a wheel and pinion, which produce a quick motion of a disk of steel placed vertically, against the periphery of which a piece of flint is held. This machine produced sufficient light to guide the miner in his operations; but it was very expensive, as every workman required a person named a miller, to give him light. This light was safe in comparison with that of the candle, when the air was dangerous; yet, in particular cases, explosions have taken place from it; and although the steel mill is now happily superceded by the safety lamp, the trial of the candle must in many cases be resorted to, particularly in sudden emergencies, arising from the inflammable air coming suddenly off while a colliery is working with candles, and judged perfectly safe. It is for this reason the detailed account is given, such test being less or more resorted to in many collieries every day, though it ought never to be tried in dangerous cases on any account whatever, except from absolute necessity, as safety lamps can be used with great expedition, and with the most complete security. Previous to the invention of the lamp, the whole mines of extensive collieries have been carried on with no other light but that produced by steam mills, as no candle could be taken into the mines without producing an explosion. This mode of working the mines was attended with an uncommon expence, great inconveniency, and imminent danger. This shews also the high value of the safety lamp in an economical point of view.

Having stated, in the preceding part of this treatise, the manner of working coals to the rise of the engine-pit shaft, we have now to state the plans which have been adopted for working coals a dipping of, and deeper than the engine-pit bottom. This has become an important point in colliery operations, and has been greatly improved within these last twenty years.

In the early periods of coal-mining, and when the running of day-levels and sinking of pits were attended with great loss of time, and uncommon expence, the working of coals under dip of the day-level and engine pit bottom was a common operation. The first plan resorted to, was running a downset mine in the coal, and carrying the water either out in pails by men, or by placing dams across the mine of about a foot or fifteen inches deep, at regular distances, so that the water was laved with scoops from the dip-head, and from dam to dam, until it reached the pit bottom, or day-level.

The next improvement was to raise the water by means of sloping hand-pumps from one dam to another, which slope-pumps had long wind-bores corresponding to the dip of the coal and range of the atmospheric pressure, with several valves to retain the water in the wind-bores in case of leakage when the pumps were not going, or pumps were placed in small pits, and the water carried in spouts from the top of one pump to the bottom of the next, until it reached the engine-pit, or day-level. This last plan was improved by laying a working barrel with a long wind-bore at the bottom of the downset mine, having a smooth rod working through a collar, at the top of the working barrel. At one side of which, near the top, a kneed pipe is attached, and from it pipes are carried to the point of delivery, either at the engine-pit bottom, or day-level, as represented in Plate CCCXCIV. Fig. 3 The spears are wrought sometimes by rods connected with the machinery at the surface, in which case, if the spears are of great length, they are either suspended from swing or pendulum rods, or move on friction rollers. But as the action of the spears, running with great velocity the full length of the engine stroke, very soon tore every thing to pieces, the motion of the spears below ground is reduced from 6 or 8 feet, the stroke of the engine, to about 15 inches; and the speed in the pump is produced by the centering of a beam, and the attachment of the spears to it, as represented in Plate CCCXCIV. Fig. 4. where *a* is the working barrel, *b* the beam centered at *c*, having an arc head and martingale sinking-chain. The spears *d* are attached by a strong bolt, which passes through the beam; and there are several holes, by means of which the stroke in the pumps can be made longer or shorter, as necessity may require. A strong iron quadrant, or wheel, at the pit bottom, regulates the movement of the spears. In level free coals, these pumps can be wrought by a water-wheel placed near the bottom of the pit; which wheel is moved by water descending the shaft, and is discharged by the day level. We have also seen a water-wheel used in the same manner, where the engine had great command of the water; and the wheel was moved either by water descending from the sides of the pit, or by water first pumped up by the engine, and allowed to discharge from the side of the pumps upon the wheel. The coals were brought up also by the same means. When water is very inconsiderable in these under-dip works, it is raised sometimes by a common forcing engine, such as is used for extinguishing fires, but of a small size; or by forcing pumps, wrought by one or two men, with a fly-wheel and pinion, the shaft having two cranks, which work two small reciprocating iron beams connected with two pump barrels. These machines have a spherical air-vessel attached, in order to keep the water in constant flow, which is a great relief to the workmen, as they have not the *vis inertiæ* to overcome every stroke or revolution of the fly-wheel.

But the greatest improvement for working under-dip coal has been brought forward by the Newcastle engineers. Their plan is, to run a mine a dipping of the engine-pit in such direction of the dip as may be most suitable; and both water and coals are brought up the rise of the coal by means of high pressure engines, which work with a power of from 30 to 50 pounds upon the square inch. These machines are quite under command, and as much power is produced in little space, they are the most applicable for under-ground work. An excavation is made for them in the strata above the coal, and the air used for the furnace under the boiler, is the returned air after ventilating the mines, the smoke is conducted in a room or board to the rise, until it is discharged into the upcast shaft, where it quickly rises to the pit top. In the dip mine a double tram road is laid, so that while a number of loaded corves are ascending, an equal number of empty ones are descending; and although this improvement has only been brought forward within these few years, under-dip workings have been already executed very nearly an English mile under-dip of the engine-pit bottom, by means of three of these high pressure engines placed at equal distances in the under-dip mine. Hence we conclude, that there is no limitation to this mode of working; and in place of contemplating the sinking of pits of excessive depth upon the dip of the coal, at an almost overwhelming expence, we are of opinion that much of the under-dip coal will now be wrought by means of the present engine pits. These great improvements in coal-mining are to be seen in full action in the Newcastle district, where coals are not only wrought under dip, and under the river Tyne, but where in an engine-pit of 115 fathoms in depth coals are now working under dip of the engine pit bottom above 1600 yards, and fully 80 fathoms of perpendicular depth more than the bottom of the pit. There are instances, where coals may be thus wrought from the dead crop and a dipping, by means of machinery placed at the crop, without cross cutting the strata by a pit, which in many situations would be a great saving, where the water and sand beds render it very difficult to pass through, and where the expence is great, amounting to above £100 per fathom. We see no physical objection to the carrying on of this system of under-dip working almost to any extent, provided the air can be circulated in abundance; and we think this can be accomplished equally well in this system as by the other.

Besides these plans of working under-dip coals, there are several others in common practice.

If an engine-pit is sunk to a particular coal, found at any given depth, all the other coals of the coal-field, both above and below the coal sunk to, can be drained and wrought to the same depth, by driving a level cross-cut mine, both to the dip and rise, until all the coals are intersected, as represented in Plate CCCXCIV. Fig. 5. where A is the engine-pit bottom reaching the coal *a*; and *b*, *c*, *d*, *e*, *f*, coals lying above the coal *a*; the coals which lie below it *g*, *h*, *i*; *k* is the forehead of the cross-cut mine intersecting all the lower coals; and *l* the other forehead of the mine intersecting all the upper coals.

An additional breast of coals, as in the above case, may be obtained, by sinking the engine-pit deeper, and running level cross-cut mines, as above mentioned. But this plan is not easily accomplished, if the water is heavy in the pit. If it is so, the plan is, to connect the wind-bore of the lower set of pumps with a kneed pipe, and make a lodgment for the water in the coal to the dip of the engine-pit bottom; to the dip hand of which tail pipes are laid from the kneed pipe, as represented in Plate CCCXCIV. Fig. 6. where the knee of the pipes rests on a strong bunton. By this plan no water descends the shaft while sinking. The additional depth is represented by the dotted lines; and the double horizontal dotted lines represent the cross-cut mines for the coals a dipping.

Another plan of working a coal under dip of the engine-pit bottom, is by means of what is termed an inverted syphon, known also by the name of a drowned or blind level, as represented in Fig. 7. where A is an engine pit sunk to the coal B, and C is a coal 10 fathoms deeper, and dipping 1 in 12. The pit is sunk to the coal C, and a mine is run in that coal a dipping to the distance of 120 fathoms to the point D. This distance is found by multiplying the distance betwixt the two coals by the dip, viz. $10 \times 12 = 120$. While the mine CD is driving, a similar mine is driven in the coal B immediately above, and in the direction of the mine CD to the point E, above the forehead D. From E to D a blind pit is sunk, or one or more bores are put down, by which all the water found in the coal from B to E descends, so that when the water rises to the top of the blind pit at E, it discharges into the engine-pit sump at C. By this operation, a new breast of coal is laid dry, of 120 fathoms in breadth, and the whole length of the coal-field. The same effect would have been obtained, by running a stone mine, or cross-cut in the direction of the dotted line CE; but the first operation being in coal, the expence is almost nothing in comparison with what the cross-cut mine would cost; and if a greater breast of coal was necessary, under-dip operations would commence at E, and the water thereof be delivered into the blind pit. This second portion of under-dip coal would require to have pumps from E a-dipping, and these could be wrought by any of the plans before mentioned.

Another method of gaining under-dip coal, where pits are not deep or very expensive, is to run a mine in the coal to any distance a-dipping, as from C to F; then to begin a pit H upon the surface, so as to be directly above the forehead F. As soon as the pit is secured to the rock-head through the alluvial cover, a bore is put down to the mine at F; by this means all the water found in the pit descends through the bore, and ascends the mine to the bottom of the engine-pit at C; by this method the pit is sunk to the depth G, without being troubled with water. G being on a level with C, the water or growth of the pit must then either be drawn up the pit H or the pit A, until the pit H is sunk to the coal at F. A set of pipes is then laid along the pavement of the coal from C to F, and carried up from the pit-bottom a few feet higher than G; there a trough is placed on the top of them. A set of pumps, of a diameter corresponding to the growth of the water, is placed from the pump at F to the height of the trough at G; and the pump-spears are connected with the coal-drawing engine at the mouth of the pit. Hence all the growth of water in the pit is conducted into the trough upon the top of the pipes, and into it also the water from the pumps is delivered. The water, by its own gravity, ascends the pipes from F to the engine-pit bottom at C, where it is drawn to the surface by the main engine.

The foregoing plans for working under-dip coals, are such as are in general practice. Of these plans there are many modifications and combinations, to suit the particular situation of a colliery.

In prosecuting the workings of under-dip coals, it requires caution not to carry the rooms or boards through upon the level or dip-head mine of the first winning, as in this case all the water of that winning would descend to the under-dip works, and drown them. This caution is particularly necessary when approaching the dip-head levels of a level free coal; for, if not attended to, the water of the level free coal, in place of going out by the day level, would go down upon the engine a-dipping, and overpower it; in all such cases, strong barriers of coal ought to be left upon the dip-side of the dip-head levels, not only to keep the water up, but to resist any crush or sit in the coal, which would have the effect of letting down the water also.

In the working of coal-mines, serious interruptions occasionally take place, even with every precaution in the management. These interruptions are, chiefly,

1st, Creeps.
2d, Crushes, thrusts, or sits.
3d, The coal taking fire.
4th, Water in extra quantity.

A creep is occasioned from the pavement being very soft, and the pillars of small area, so that they sink into the pavement, and produce a movement in all the superincumbent strata. If once the creep begins, it is almost impossible to prevent it overrunning all the workings. If the soft pavement is thin, it will only heave up a little, and no great injury will arise to the works; but if the pillars are very weak, they are liable to give way, and produce a crush. When the soft pavement is of considerable thickness, the pillars sink very much, until the upheaved pavement meets the roof, and shuts up the workings altogether. This misfortune is generally rectified by driving mines through the creep to the whole coal wall, and then opening up the works anew. From the improved system of mining introduced at Newcastle, the pillars in the creep are frequently wrought by taking away the upheaved pavement. This operation has been greatly facilitated since the introduction of the safety lamps. The only effectual plan for preventing creeps, is to work the mines with narrow boards, and very large pillars, which is no loss, as all the pillars can be got out afterwards.

A crush is produced in general by the pillars being left too small to resist the weight of the superincumbent strata; or it is produced sometimes where the pillars are abundantly strong, but where the strata in the roof are very soft, and composed of argillaceous earth or fire-clay; this kind of roof breaks along the side of the pillars, and falls down, after which the fire-clay above the heads of the pillars crumbles, from the pressure and exposure to the air, and a crush ensues. Crushes are prevented by keeping the pillars large; and where the roofs are bad, the boards must be very narrow. When a crush commences, it is almost impossible to prevent it overrunning all the work, except it is resisted by a barrier of coal, or by stronger pillars in another district of the work. In wastes of very great extent, the progress of a crush is sometimes stopped by cutting out a line of pillars betwixt the crush and the wall-faces, so that when the crush comes to the void, the superincumbent strata break down from the waste to the surface. When a crush overruns the whole work, the superincumbent strata break over at the wall-faces. When this happens, the works have to be opened up anew, by cutting roads and making air-courses through the crushed waste. When creeps and crushes are extensive, they derange the whole economy of the work, by destroying all the roads and air-courses; and the re-establishment of the works is attended with uncommon hazard, labour, and expense. The improved plan of working the mines in pannel-work, as brought into practice by Mr. Buddle, is highly beneficial in preventing creeps or crushes, and if they do take place in one pannel of work, the pannel-walls act as complete barriers against their extending to the other pannels.

When the pillars of a colliery are to be wrought by taking a part of every pillar, it sometimes happens that the remaining portions of the pillars resist the weight of the superincumbent strata for a considerable time. In this case there have been instances of the weak pillars giving way in a moment, without warning, and forcing the air of the waste up the shafts with inconceivable force; a case attended with imminent danger to the workmen.

Coal-mines take fire either from explosions of inflammable air, or spontaneous ignition, occasioned by the decomposition of pyrites amongst the rubbish of the mine. The method adopted for extinguishing such fire, when occasioned by inflammable air, has been already mentioned, when treating of ventilation. In coals liable to spontaneous ignition, the effectual plan of prevention is, to allow none of the small coal and rubbish to remain in the wastes; but if this cannot be done, the old wastes should be insulated from the new works, by buildings betwixt the surrounding pillars, to prevent the access of air to the rubbish. When wastes containing this kind of rubbish take fire to any considerable extent, the pplication of water has very little effect; for though it may in some degree extinguish the fire at that particular spot, it greatly promotes ignition amongst the adjoining rubbish, by bringing on a more rapid decomposition of the pyrites. The remedy in common practice is, to build off the burning waste with air-tight walls, and prevent all access of air. Though these remedies generally prevent the fire from spreading farther, a very slow combustion frequently goes on for many years in the ignited wastes. There have been instances of this kind of fire continuing for near a century. When coals which are free of pyrites take fire by accident, if they cannot be extinguished by any of the methods before mentioned, the last resort is, to allow the wastes to fill with water until the fire is extinguished. This method cannot be applied in coals liable to spontaneous ignition, for as soon as the water is drawn from the wastes, this ignition would take place through the whole extent of the works.

In prosecuting the workings of a colliery, the ordinary growth of water which is pumped up by the engine, is sometimes suddenly increased from fissures in the strata communicating with great bodies of water. Such additional feeders are measured as to quantity every day, in order to find if they abate or not. If they do not abate, and the engine is unable to draw this additional quantity, more machinery must be put on to keep the mine dry; but if this cannot be effected, and the growth of water be so great as to threaten the ruin of the colliery, this extra growth is frequently kept back by placing strong dams of wood in the mines leading to the district from whence the water issues. This may be done where there is a strong barrier wall, and a few narrow mines through it; but it is altogether impracticable along an extended line of pillars. These dams are made of very dry fir logs, about six feet in length, each log being dressed smooth and square with a plane. A seat is cut in the mine, where the dam will lie most secure, the inner head next the water being wider than the other end. In order the more effectually to resist the pressure, each log is dressed to this bevel, and the sole of the dam is laid with a bed of oakum before the logs are laid down, a strong cast iron pipe, of size sufficient to let a man pass through, is placed in the dam, which pipe is of a conical shape, the wide end being towards the inside, the whole space is then filled up with logs. The outer and inner heads of the dam are then wedged in a regular manner, in lines parallel to the joints of the logs, with very thin dry fir wedges, and that until no more wedges can be driven. The men for wedging the inner head, pass and repass through the iron pipe; and the last of these, when the wedging is completed, draws after him a wooden plug, which shuts up the iron pipe, and prevents the water from passing through. This plug is longer than the dam, so that a piece of it projects beyond the lower end, by which it is drawn tight into the pipe, and then made perfectly tight by wedging. If more dams than one have to be put in, the iron pipe is only necessary for the dam which is to be last wedged. Dams of this kind will resist almost any pressure of water; but if the roof or pavement is bad, particularly the latter, there have been instances of the water, from its excessive pressure, passing through the strata under the dam, and blowing up the pavement at the lower end of it, by which the colliery has been instantly ruined, and the lives of the men put in imminent hazard; the same accident is liable to happen by the water passing under the barrier walls, or bursting it where thin. It is not found expedient, where there is great pressure, to form these dams in the boards or rooms, the width being too great: mines of about six feet wide are preferred. Water has, by this plan, been kept back under a pressure of 130 fathoms. Plate CCCXCIV. Fig. 9. represents the plan of a dam in a narrow mine, for resisting a great pressure. Fig. 10. represents a plan of a dam placed in a room or board, where the pressure is much less.

In cases where the communication from an extra feeder of water to the engine pit-bottom, is through a staple or blind pit, such water is prevented from descending to the workings, either by a very strong water-tight scaffolding, made of timber, supported by diagonal stays from the sides of the pit below, or a stone arch may be thrown in the pit, and covered with a thick moating of clay; these are generally placed at a bed of the strata which is impervious to water.

In collieries where water is thus kept back with so heavy a pressure, the greatest caution is required in conducting the adjoining workings, in not approaching too near, the danger being so imminently great.

The working of mines of limestone and ironstone is conducted on the same principles as those of coal. The greater part of the limestones of Great Britain are wrought open cast, similar to a freestone quarry: When they are wrought under cover, it is always with post and stall; and, if the roof is good, the pillars are very small, and the mines very wide. The general system of working is the same as that of coal on the simplest form, little attention being required for ventilation.

Ironstone is sometimes wrought open-cast; and in hill districts where it abounds, as in Wales, the plan of damming and husshing is employed, that is, collections of water are made above the open-casts, and the water from above is allowed to pass through them, which carries down both the ironstone and the argillaceous clay in which it is embedded; when the water ceases to run, the ironstone is gathered at the bottom of the slope. When ironstone is found in the strata immediately above a coal, the practice is, to work the coal first, if in the post and stall system; afterwards to take down the roofs of the rooms and thirlings, and pick out the ironstone. In this way none of the ironstone above the pillars of coal can be got; but if the common roof-stone comes down in great quantity, the wastes can be so built up as to allow both the pillars of coal and the ironstone above them to be taken away. Ironstones in the roof of coals sometimes render the coal easily wrought in the Shropshire style, both the coal and ironstone being wrought at once, while the roof-stones fill up the waste, and serve as gobbing, so that none of the coal is required for that purpose. Much ironstone is wrought in the solids, that is, simply as an ironstone mine, and as the ironstone is in bands and balls of a few inches thick, much of the argillaceous schistus in which it is embedded has to be wrought, in order to give the men room. In this case the Shropshire style is universally adopted; but as the ironstone taken out bears so small a proportion to the waste which is formed, a great part of the waste stuff has to be brought out of the mine to the surface, there not being stowage for it below; this stuff covers so much ground, that it forms a great objection to the working of ironstone under valuable land. When it happens that a coal is working in the post and stall system, a few fathoms either above or below the ironstone mine, a cross-cut mine is sometimes run from the ironstone workings to those of the coal: through this cross-cut the waste stuff is carried, and stowed up betwixt the coal pillars, by which means the greater part of the pillars can easily be wrought out, which is a great advantage.

The most extensive collieries in Great Britain are wrought for sea sale, and are frequently situated at the distance of several miles from the place of shipping, to which the coals are conducted in waggons upon cast-iron rail-ways. Waggons of various dimensions have been adopted, containing from 10 cwt. to 3 tons. When the waggons contain a great weight, the rails require to be very strong, and are of course expensive. From 15 to 30 cwt. is perhaps the most suitable for colliery rail-ways in general. When the declination from the colliery to the shipping place is moderate, one horse can take down 8 waggons at a time, each waggon containing a ton weight of coals, and return with the empty ones. Where great declivities occur, inclined plane machines are used, by which the full waggons, in descending, pull up the empty ones; if steep ascents occur betwixt the colliery and the shipping place, the waggons are taken up by means of a steam-engine placed at the top of the bank. This is attended with considerable extra expense, and it is only at collieries where a great quantity of coal is to be vended that this expense can be repaid. Upon some rail-ways, high pressure travelling engines have been adopted for taking down the coals, and with very great effect, particularly by Mr. James Stevenson, engineer at Killingworth colliery, Newcastle, and by Mr. Blenkensop at Leeds. The former has made great improvements, both in the construction of the engines and rail-ways. By Mr. Blenkensop's plan, teeth are cast on the side of the rail, by which means, with a toothed wheel, the engine can draw the waggons up a declivity of considerable steepness. One of these engines can draw from 30 to 50 tons at a time. For the particular construction of rail-ways and travelling engines, see the article RAIL-WAY.

The dividing of great coal into separate kinds, termed great coal, chews, and small coal, is a very bad system: the best mode for the mine master and consumer is, to have only two kinds, viz. household coal and culm; the household coals being composed of large coals, and of a size downwards to about an inch, separated from the culm by a harp, or by a riddle, which is preferable. This correct practice is to be seen in all the collieries of the Glasgow district in Scotland; by it the greatest economy is produced, not only in respect of the coal, in a given area, producing the greatest quantity of marketable coals; but the open burning coals, when free from culm, are the best fitted for every general purpose; whereas the culm can be afforded at a very cheap rate for steam-engines, lime-burning, salt, and brick-making, it being well known that when culm is mixed with the round coal, it retards the burning in an uncommon degree. The great coal system, where three sizes are made, is attended with much loss of coal, and greatly enhances the price of what is termed great coals, these being generally 30 per cent. dearer than the chews, while, at the same time, they must be broken down to the size of chews by the consumer, before they can be put into the fire. This shews how very detrimental this system is.

At Newcastle, where the coals are of a rich caking quality, and where every particle of them is of equal value, a very bad system has been introduced, of separating the smaller part of the coal from the other, by means of skreens or harps. The small coal forms excellent smithy coal, very fit for glass-making, and indeed for almost any purpose. This separation of the small coal arose from the violent competition of the coal owners in the London market, in order to give the coals a better appearance. The system was very easily introduced, but it has now extended to such a degree, that it seems to carry ruin with it as to the economy of the coal-fields in the north of England, for the fine coals thus separated cannot be sold; the consequence is, that at every colliery they accumulate to such a degree, that they are either allowed to take fire by spontaneous ignition, or are actually set on fire in order to clear the ground of them. It is the burning of this kind of coal which astonishes all strangers who approach Newcastle at night, from the innumerable bright blazes seen in every direction. The waste and destruction of coal by this system has extended now to such an uncommon degree, that it is estimated that, upon the collieries of the two rivers Tyne and Wear, not less than 500,000 tons, or rather more than half a million of tons, are thus destroyed every year. This is a lamentable waste of our coal mines, and the cause of deep regret, not only to those concerned in the mines, but to every one who views the evil in its proper light; particularly when it is considered, that the mines at Newcastle have now reached the depth of 200 fathoms, and that the capital required for one colliery establishment amounts from 50,000*l.* to 100,000*l.* The coal-fields of Great Britain are, no doubt, of great extent, and the quantity of coal remaining to be wrought almost beyond calculation; but they have a limit, and are exhaustible. Although the coal-fields are indeed of great extent, the increased depth of the Newcastle pits, and the immense capitals now required for colliery establishments, demonstrate in the clearest manner, that, as to that district, its very wonderful magazine of the finest coal in the world is quickly exhausting, and cannot now be wrought but at greatly increased expenses. The proportion of coal thus wilfully destroyed by fire each year, is estimated to be from a sixth to a seventh of the whole annual output of coals in that district.

This destruction of coals is a direct, irretrievable national loss; for it must be allowed, by any one who contemplates the energies and physical powers of Great Britain, compared with those of the other empires and kingdoms of the world, that it is the abundance and cheapness of its coals, with its innumerable steam-engines, which constitute one prominent point of its energies and powers, and, as a manufacturing country, give its comparatively limited population an effective strength, far beyond any nation in the world. Without coals there could be no steam-engines; and the steam-engines in Great Britain do the work of many millions of people. If, in idea, we abstract the cheap coals and steam-engines from our manufacturing establishments, our superiority as a manufacturing country would cease; and if we lose this superiority, it is but too evident to any person of observation, that we would sink instantly from the very high point of the political scale to which we have attained amongst the nations of the world. From this view, the high importance of the coal-mines of Great Britain may be estimated both in a civil and political point of view; and, therefore, whatever system tends to waste so valuable a commodity is greatly to be regretted. Those who, by their industry and attention, bring forward plans by which any given area of coal produces the highest proportion of marketable coals, do the community a very great service, and they deserve well of their country. It is by the moderate price of coals and the steam-engines, that Great Britain, as a manufacturing country, can produce its manufactures at a more moderate rate than any other nation, although the wages paid for manual labour at the manufactories, are at least three times more than what is paid for labour in other parts of the world. In short, the prosperity of Great Britain has, in a very great degree, been maintained by the abundance and cheapness of its coals; and its future prosperity, to all human view, must depend upon this point of economy. Whatever tends to enhance the price of coals, tends to injure Great Britain in its vital principles. The government has, at various times, proposed *an excise upon coals at the pit mouth*, a proposition which has always been vigorously and effectually opposed. It must be very evident to any one who considers the subject, that a more impolitic tax could scarcely be devised, particularly when we compare the situation of Great Britain, as a manufacturing country, with the other nations of the world: The effects of such a tax would be immediate ruin to the whole manufacturing interest, and consequently to the empire.*

Erratum in p. 343. col. 1. line 9. from top, for *bluish* read *blush*.

MINERAL WATERS.

Waters are divided into different classes, according to the source from which they are derived, as, Rain, Snow, and Hail water, Spring and River water, Well water, and the water of Lakes and Ponds. The first of these is the purest, particularly if it be collected at a distance from town, and some time after a shower has continued. It contains air and carbonic acid, carbonate and muriate of lime; but the quantity of these is so small that rain and snow water may be used for many of the purposes for which distilled water is employed.

The other waters contain some of the soluble substances over which they pass. The quantity of foreign matter in these is in general not great; hence they are sufficiently pure for domestic purposes.

The water of some springs, however, often contains a considerable quantity of foreign ingredients, which impart to it particular properties. Waters of this kind are called *mineral waters*. Besides these, there are some waters called also mineral, which have very little foreign matter, such as the waters of Matlock and Malvern. These, however, strictly speaking, are not mineral waters.

Mineral waters occur in different parts of the globe, differing in the ingredients which they contain, according to the channel over which they have flowed; besides this, they also differ in their temperature. Most of them are of the same temperature with the surrounding medium; occasionally, however, they are warmer, and, in some rare instances, they are at a boiling heat.

Though the attention of man was early directed to these waters, particularly from their medicinal effects, it was not till about the end of the 17th century, that any chemical investigation of them was undertaken.

Boyle, in 1663, seems to have been the first who employed tests to detect the substances contained in mineral waters. To these there were various additions made by Duclos, by Hierne, and again by Boyle in 1678. In 1707 Geoffroy pointed out the method of procuring the solid ingredients by evaporation; and in 1726 Boulduc employed alcohol as the means of separating the saline substances from their solution in the water. At this time carbonic acid, an ingredient so common in mineral waters, and which is the agent by which many of the other substances are rendered soluble, was not known. After the discovery of this gaseous fluid by Dr. Black, the labours of chemists were directed to mineral waters, more particularly after the publication of the essay of Bergman in 1778. Since then, numerous mineral waters have been subjected to analysis, by Black, Klaproth, Westrumb, Fourcroy, and others; the result of whose labours, and the different methods of analysis used by them, were published in the works of Kirwan and Saunders, in 1800. Of late, Dr. Murray has brought forward a new view of the composition of these fluids, which threatens to overturn the results of the experiments of former chemists, and which has induced him to propose a method of analysis, more simple than those generally followed.

The examination of mineral waters, is perhaps one of the most difficult pursuits of the chemist. It requires an intimate knowledge of the action of bodies on each other, and the utmost nicety in the manipulation; the quantity of matter on which he has to operate being so minute. In the analysis of these fluids, the various processes recommended should be tried and compared, and, if necessary, repeated till they agree in their results.

The examination of a mineral water may be divided into two parts; 1st, The investigation of the physical qualities of the water, with an account of the surrounding objects; 2d, The chemical analysis of the fluid, so as to ascertain its component parts.

Of the Physical Qualities of the Water, &c.

Before proceeding to the chemical investigation of a mineral water, it is necessary to ascertain the source from which it is derived, the nature of the substances over which it has passed, and of the soil where it has its exit. We must likewise attend to any matter which may be deposited from it. Its taste, odour, colour, and temperature, must be observed, and the quantity of it discharged in a given time, and the rapidity with which it flows, must likewise be noticed. This examination of the water ought to be performed at different times of the day, and in different seasons, both before and after rain, as the quantity of the fluid discharged, and of

* The Editor has been indebted for the preceding valuable Article on Coal Mines to Robert Bald, Esq. F. R. S. E. &c.

course its properties, vary according to the state of the weather. By the knowledge thus acquired, some information may be gained with respect to the nature of the water, and of the substances which are contained in it; thus the odour and the taste point out whether it be sulphureous or contain iron, and its sparkling indicates the presence of an aërial fluid.

Having made these observations, the next step, is to proceed to the chemical investigation of the fluid.

Of the Substances found in Mineral Waters.

The substances found in mineral waters may be divided into the gaseous fluids, the acids, the alkalies, the earths, and the compound salts.

1. *Atmospheric air* is contained in almost all mineral waters, the quantity however is not great, as it seldom exceeds the $\frac{1}{28}$th of the volume of the water. It was first pointed out in those fluids by Mr. Boyle.

2 *Oxygen gas* was found in mineral waters by Scheele. It exists in small quantity, and is never contained in the same water with sulphuretted hydrogen or the compounds of iron.

3. *Nitrogen gas* was detected in the Bath waters by Dr. Priestley, in Buxton waters by Dr. Pearson, in those of Harrowgate by Dr. Garnet, and in those of Lemington Priors by Dr. Lambe.

4. *Carbonic acid* is a very common ingredient in mineral waters; it was first discovered by Dr. Brownrigg in those of Pyrmont. Its quantity varies considerably, though in general it seldom exceeds that of the water. According to Higgins, however, 100 cubic inches of Pyrmont water contain 160, and, according to Westrumb, no less than 187 cubic inches of carbonic acid.

5. *Boracic acid* has been found in some of the lakes of Italy, though, in the waters in which it has been observed, it in general exists in a state of combination.

6. *Sulphureous acid* has been detected in some of the waters of Italy near volcanoes.

7. *Sulphuretted hydrogen* is a very common ingredient in mineral waters. It was first discovered in them by Scheele.

8. *Soda* is the only alkali which has been found, in its free state, in mineral waters. According to Dr. Black it exists in the waters of Geyser and Rykum, in Iceland.

9 *Lime* also, in its pure state, is said by some chemists to exist in mineral waters.

10. *Silica* exists in the waters of Geyser, and in many others. It was generally supposed that the earth was held in solution by soda; this however does not seem to be the case, as the quantity of alkali in the waters containing silica is so trifling.

Nitric, carbonic, sulphuric, and muriatic acids, and sulphuretted hydrogen, are frequently found in mineral waters, in union with potassa and soda, with lime and magnesia, and with the oxide of iron. Baryta, alumina, and the oxide of copper, have also been found in combination with some of the above-mentioned acids, though less frequently than the other bases. Subborate soda has likewise been detected in the lakes of Thibet and Persia; these waters, however, do not belong to those properly called mineral waters.

The *nitrates* are rarely found in mineral waters.

11. *Nitrate of potassa* has been detected in some of those in Hungary, and in the salt springs in Germany.

12. *Nitrate of lime* was first discovered to exist in water by Dr. Home. It is is found also in some springs in the Deserts of Arabia.

The *carbonates* are perhaps the most frequent of the compound salts contained in mineral waters.

13 *Carbonate of potassa* has sometimes, though rarely, been found. When present, it is in small quantity.

14. *Carbonate of soda* is a much more abundant production, being contained in a great many waters.

15. *Carbonate of ammonia* is seldom detected.

16. *Carbonate of lime*, in union with an excess of carbonic, is perhaps the most common ingredient in mineral waters, few waters existing without it. 1000 parts of water by weight, when they contain 2 of carbonic acid, can dissolve 2 of carbonate of lime. As the quantity of water increases, the carbonic acid necessary to hold the carbonate of lime in solution becomes smaller. Whatever be the quantity of carbonic acid in water, it is able to hold the carbonate of lime in solution, provided the carbonic acid exceed the weight of the lime.

17 *Carbonate of magnesia* is frequently found in mineral waters, also held in solution by an excess of acid.

18. *Carbonate of alumina*, according to Westrumb, exists in the waters of Weinberg and Pyrmont; it is doubtful, however, if this be the state of combination of the alumina.

19. *Carbonate of iron* is often contained in mineral waters. When iron is present in water, it is almost always in union with carbonic acid; the carbonate being held in solution by an excess of acid.

The *sulphates* are not so frequently found as the carbonates.

20. *Sulphate of soda*, however, often occurs.

21. *Sulphate of ammonia* has been detected in some springs near volcanoes.

22. *Sulphate of lime* is a common ingredient in mineral waters.

23. *Sulphate of magnesia* frequently exists. It is contained in the waters of Epsom; hence the name of the salt Epsom Salt.

24. *Sulphate of iron* is often found in waters in the neighbourhood of volcanoes. It has also been detected in other waters, as in those of Horley Green by Dr. Garnet, and in the waters of Denmark by Bergman.

25. *Sulphate of copper* is a very rare production in mineral waters. It is found only in those which issue from copper mines.

The *muriates* are very frequently observed in waters.

26. *Muriate of potassa*, however, rarely exists.

27. *Muriate of soda*, on the contrary, is found in almost all mineral waters.

28. *Muriate of ammonia* has been detected in some lakes in Italy.

29. *Muriate of lime* and *muriate of magnesia* are often found.

30. *Muriate of baryta* and *muriate of alumina*, it is said, exist in some waters, they are however very rare; the former has been detected by Withering, the latter by Bergman.

31. *Muriate of manganese* is found in some waters. According to Lambe it is contained in those of Lemington Priors, and Dr. Scudamore has found it in the water of Tunbridge wells.

32. *Hydro-sulphuret of soda* has been observed in some waters.

33 *Hydro-sulphuret of lime* also, though rarely, exists in them.

It mus ibe here remarked, that the salts mentioned above, as existing in mineral waters, are those which have been procured by the evaporation of the fluid, hence inferring, that those deposited by evaporation are the salts which the water contained. Other views are, however, entertained with respect to the state of combination of the acids and bases, which, if correct, will make the salts different from those stated.

Besides the substances enumerated, mineral waters contain animal and vegetable bodies; these, however, are probably accidental.

From the above statement, it would appear that a mineral water contains an immense variety of ingredients; this, however, is not the case. A mineral water seldom contains above 8 or 10 of these substances; indeed it rarely happens that the number is so great. In general it does not exceed 6. The substances most commonly found are, free carbonic acid and sulphuretted hydrogen, carbonates of soda, lime, magnesia and iron, sulphates and muriates of soda, lime and magnesia. Owing to the waters containing some of these ingredients, while the others are wanting, or in small quantity, they have been divided into different classes, and named according to the substance which imparts to them their particular properties.

Mineral waters are divided into four classes, the *acidulous*, the *sulphureous*, the *chalybeate*, and the *saline*.

Acidulous waters are those which contain carbonic acid in its free state, or in combination in excess with a base. These waters are easily distinguished by their slightly acid taste, and by their sparkling when poured from one vessel to another; both of which properties they lose, when exposed to the air for a length of time, or by boiling. Besides carbonic acid, they almost always contain muriate of soda, and some of the earthy carbonates; it is the free carbonic acid, however, that imparts to them their particular properties.

Sulphureous waters are those which contain sulphuretted hydrogen. These are very easily distinguished by their odour, and by their rendering a solution of a salt of lead black, or by causing a piece of silver, when immersed in them, to acquire a dark colour. Besides sulphuretted hydrogen, they in general contain alkaline and earthy sulphates and muriates. The sulphureous waters may be subdivided into two kinds; 1st, Those which have sulphuretted hydrogen in its free state: 2d, Those in which it exists in union with an alkali or an earth.

Chalybeate waters are those which have iron as an ingredient. These are known by their peculiar taste, and by their becoming black when mixed with an infusion of nutgalls. The chalybeate waters are of different kinds; sometimes the iron is combined with sulphuric acid, more frequently it is in union with carbonic acid; this may be just in sufficient quantity to hold the iron in solution, or it may be in excess, in which case, besides chalybeate, the water possesses acid properties, forming what is called an acidulous chalybeate water.

Saline waters are those which contain the saline ingredients generally found in mineral waters, but which have not carbonic acid in excess, and are free from sulphuretted hydrogen and iron, or contain them in very trifling quantity. Saline waters may be subdivided into four kinds.

(*a*) Alkaline waters, or those which contain alkali in its free state, or combined with carbonic acid, and which render the vegetable blues green.

(*b*) Hard waters, or those which contain carbonate or sulphate of lime.

(*c*) Salt waters, or those in which muriate of soda abounds.

(*d*) Purgative waters, or those which contain principally sulphate of magnesia.

The following Table shows the component parts of a Gallon of the principal Mineral Waters.

Classes.	Names.	Tem.	Gases Cubic Inches				Grs. of Carbonates of				Sulphates of			Muriates of			Silica	Oxide of Iron.
			Oxygen.	Nitrogen.	Carbonic Acid.	Sulphuret. Hydrogen.	Soda.	Lime.	Magnesia.	Iron.	Soda.	Lime.	Magnesia.	Soda.	Lime.	Magnesia.		
Acidulous	Seltzer	Cold	—	—	138	—	32	24	40	—	—	—	—	140	—	—	—	—
Sulphureous.	Harrowgate	Cold	—	7	8	19	—	18.5	5.5	—	—	—	10.5	615.5	13	91	—	—
	Moffat	Cold	—	4	5	10	—	—	—	—	—	—	—	36	—	—	—	—
Chalybeate	Brighton	Cold	—	—	18	—	—	—	—	—	—	32.7	—	12.2	—	6	1.12	11.2
	Tunbridge	Cold	1.4	5	10.6	—	—	—	—	1	—	1.25	—	0.5	—	2.25	—	—
	Bath	116	—	—	9.6	—	—	6.4	—	—	12	72	—	26.4	—	—	1.6	.016
Acidulous Chalybeate	Spa	Cold	—	—	104	—	11.7	11.7	35.3	—	—	—	—	1.37	—	—	—	4 5
	Pyrmont	Cold	—	—	208	—	—	34.8	80	—	—	68.6	44.5	12.4	—	—	—	4.5
	Carlsbad	165	—	—	32 to 50	—	39	12	—	—	70	—	—	34.6	—	—	2.5	.125
	Cheltenham	Cold	—	15	30.36	—	—	—	—	5	480*	40	—	5	—	25†	—	—
Saline.	Sedlitz	Cold	—	—	—	—	—	6.7	21	—	—	41.1	1444	—	—	36.5	—	—
	Buxton	82	—	2	—	—	—	10 5	—	—	—	2.5	—	1.7	—	—	—	.25
	Bristol	74	3	—	30	—	—	13.5	—	—	12.5	11.75	—	4	—	7.25	—	—
	Pitcaithly‡	66	—	—	8	—	—	—	—	—	—	—	—	0 0	180	—	—	—

Of the Chemical Analysis of Mineral Waters.

In the analysis of mineral waters the first object is, to ascertain the different substances which they contain; the next is, to find out the quantity of each ingredient; and lastly, to ascertain in what state of combination

* And carbonate of soda.

† And sulphate of magnesia.

‡ This is given by Dr. Murray, according to the mode of analysis recommended by him, to be afterwards stated.

these substances exist, and what are the proportions of the different compounds which they form.

Of the Method of detecting the different Substances contained in Mineral Waters.

The substances employed in detecting the ingredients of mineral waters, are called *Tests*. By the addition of these to the waters, different appearances are produced, by which we are enabled to judge of the presence of those bodies which they contain. The tests required must be very delicate, as the quantity of matter to be indicated, is often very small. In many cases, it is necessary to evaporate the fluid to a certain extent, before some of the substances which are present can be detected.

34. *Carbonic acid*, in its free state, is easily detected. Water, when it contains this acid, sparkles when poured from one vessel to another. When it is added to an infusion of litmus, the blue is converted to red, and on boiling the fluid, or by exposing it for some time to the air, the original blue is restored. If the water be boiled, and then added to the litmus, no change in the colour takes place.

Water containing carbonic acid gives a white precipitate when added to lime water, which is soluble in nitric and muriatic acids. When also an excess of carbonic acid water is added to the precipitate formed with lime water, the precipitate is dissolved, and by boiling the fluid, the superabundant carbonic acid is expelled, and the carbonate of lime is again deposited.

35. *Sulphuretted hydrogen.* Water containing this acid reddens litmus, and when the fluid is exposed to the air for some time, or is boiled, the blue is restored. In this respect it resembles carbonic acid, and may therefore be mistaken for it. There is, however, little danger of this, as sulphuretted hydrogen is easily distinguished by other tests. Sulphuretted hydrogen is known by the odour which it emits. When water containing it is added to a solution of a salt of lead, as the acetate, it throws down a black precipitate. A piece of silver when immersed in it acquires a dark colour.

36. To ascertain the nature of any other gaseous fluids besides carbonic acid and sulphuretted hydrogen, a retort must be filled about two-thirds with the water, and the mouth of it made to terminate under a jar, filled with mercury and inverted in the mercurial trough. The water is then to be boiled for a quarter of an hour, by which the gaseous fluids will pass over into the jar. The elastic fluids which are given off, may be common air, oxygen, nitrogen, carbonic acid, sulphuretted hydrogen, and sulphurous acid; the two last, however, never exist in the same water.

37. If *sulphuretted hydrogen* be present, it must be removed by the addition of nitric acid to the water, which will absorb the elastic fluid.

38. If the gaseous fluid contain *sulphurous acid*, on the introduction of the peroxide of lead its volume will be diminished.

39. The presence of *carbonic acid* may be known by admitting a solution of potassa, which will absorb it.

40. *Oxygen* may be discovered by exposing the residual air to the action of the solution of sulphuretted hydro-sulphuret of potassa or of lime, which will absorb the *oxygen*; if what remains extinguish the flame of a candle, it is *nitrogen*.

41. The *fixed acids* rarely exist in their free state in mineral waters. If they do, the water gives a red colour to litmus, which does not disappear on boiling the fluid. The acids when in combination are easily detected.

42. *Sulphuric acid* is detected by the addition of baryta, which gives a white precipitate with any fluid containing a sulphate.

Other tests indicate the presence of sulphuric acid, as nitrate of lead. This, however, is fallacious, as it gives precipitates with other substances besides sulphuric acid.

In using baryta as the test of sulphuric acid, we must be aware that carbonic acid likewise gives a precipitate with baryta; but this is easily distinguished from that occasioned by sulphuric acid, the latter being insoluble, the former being soluble in muriatic and nitric acids.

Nitrate or muriate of baryta is, in general, preferred to the pure earth, as sulphuric acid is by them more easily separated from the substance with which it is in union, owing to the decomposition of the sulphate being effected by double elective attraction. The most powerful of the barytic salts is the muriate. According to Bergman this indicates the presence of sulphuric acid, though diluted with a million parts of water.

43. *Muriatic acid* is easily detected by nitrate of silver, which gives a white precipitate, with water containing a muriate. Nitrate of silver, however, gives a white precipitate, when added to water containing free alkali or sulphuric acid. If the former be present, it must be saturated with nitric acid; if the latter exist in the fluid, it must be precipitated by baryta or its nitrate. The salt of silver likewise gives a white precipitate with carbonic acid. This, however, is soluble in nitric acid, while that occasioned by the muriatic is not. If the water contain carbonic acid, previous to adding the nitrate of silver, it will be necessary to expel it by the addition of nitric acid and boiling.

44. *Boracic acid* is detected by means of a salt of lead, with which it forms a white precipitate; but as lead is precipitated by sulphuric and muriatic acids, it is necessary to remove these by means of the acetates of strontia and silver, having previously saturated the alkalies and earths with acetic acid.

45. The presence of an *alkali*, or an *alkaline earth*, in its free state, may be known by the green colour which it imparts to the vegetable blues, or by changing the colour of turmeric to brown. This test, however, does not point out the particular substance present. We must, therefore, have recourse to other means.

46. *Potassa* and *soda* may be distinguished from each other by two different tests, muriate of platinum and tartaric acid.

When the solution of muriate of platinum is added to water containing potassa, a yellowish precipitate falls, which is not the case when soda only is present.

47. When tartaric acid is added to a fluid containing potassa, at first there is no visible change; but when the acid is added in excess, a white precipitate is formed, provided the water be not in very large quantity compared to that of the alkali. The precipitate formed is soluble in nitric and muriatic acids; but tartaric acid, when added to a fluid containing soda, does not occasion any perceptible change.

In using tartaric acid as a test of potassa, the fluid must be concentrated by evaporation, otherwise the supertartrate of potassa is not deposited, being soluble in a large quantity of water. These tests also distinguish potassa from soda, when they are in combination with an acid.

48. *Lime*, in union with carbonic acid, is easily detected by boiling the fluid, by which means the superabundant carbonic acid is driven off, and the carbonate of lime is deposited, the precipitate being soluble in nitric and muriatic acids, and also by the addition of water containing carbonic acid. Lime, however, frequently exists combined with a fixed acid. When this is the case, no change takes place on boiling the fluid. The most delicate test of the presence of lime, when in this state, is oxalic acid. This, when added to water containing a salt of lime, gives a white precipitate, which is soluble in nitric and muriatic acids. In using oxalic acid as a test of lime, we may employ either the acid pure, or in combination with ammonia. The latter, though not the most delicate, is the best, as the alkali combines with the acid with which the lime is in union, and prevents it from acting on the precipitate. If any free acid be present in the water, it must be neutralised by ammonia, and, if we have reason to suspect the presence of baryta, it must be precipitated by sulphuric acid. Oxalic acid, it must be remarked, likewise occasions a precipitate with magnesia; but the precipitation of this earth does not take place for many hours, while that with lime occurs the moment that the oxalate is added.

49. *Baryta* may be detected by the addition of sulphuric acid, with which it gives a white precipitate, not soluble in nitric or muriatic acid. Previous to the addition of the acid, it is necessary to remove the lime, as it may, if present in considerable quantity, also occasion a white precipitate with it.

50. *Magnesia* is precipitated by the alkalies and by lime. These tests, however, are liable to fallacy. Thus, if carbonic acid be present, and we employ lime as the test, carbonate of lime will be precipitated. If the water contain sulphuric acid, sulphate of lime may likewise be formed and deposited. When ammonia is used as the test of magnesia, if carbonic acid be present, carbonate of ammonia will be generated, which, if the water contain a salt of lime, will be decomposed, and carbonate of lime will be precipitated. In detecting magnesia, then, if we suspect the presence of the other substances mentioned, nitric acid must be added, to decompose any carbonate, and the fluid boiled. The sulphuric acid must then be precipitated by baryta.

The alkalies and lime-water also precipitate alumina: this is another source of error, in using those bodies as a test of magnesia. Alumina, however, rarely occurs in mineral waters; if it does, and is precipitated along with the magnesia, it is easily separated from that earth. For this purpose, after washing the precipitate, it must be boiled in a solution of potassa, by which the alumina is dissolved, and the magnesia is left. Or, the precipitate may be dissolved in strong muriatic acid, and an alkaline carbonate added to the solution; the precipitate which is thrown down by this must be washed and dried at the temperature of about 100. Diluted muriatic acid is then to be poured on it, which will dissolve the magnesia, but will not act on the alumina.

51. *Alumina* is detected by the methods just described for discovering the presence of magnesia. Succinic acid, or its compound with ammonia, is another test of alumina, as it precipitates this earth, but does not affect magnesia; the former methods are, however, generally employed.

52. *Silica* may be discovered by evaporating the water to dryness, and adding muriatic acid to the residue. If silica be present, it will be left undissolved, and will, when mixed with a small quantity of soda, and subjected to a strong heat, form a glass; if the quantity of soda be greater, the substance formed will be soluble in water, and the solution on the addition of an acid will deposit the silica.

53 *Iron* is very easily detected in mineral waters. The triple prussiate (*ferro-cyanate*,) of potassa, when added to the solution of a salt of iron, gives a blue precipitate. This, however, does not take place, if the water contain any uncombined alkali. If this be present, therefore, it must be neutralized, before adding the prussiate. If the iron also be in the state of protoxid, which is seldom the case, the precipitate is white; it is necessary, therefore, in some instances, before using the prussiate, to add a small quantity of muriatic acid, by which the protoxide will be converted to peroxide, and will give the blue precipitate with the prussiate.

Some have objected to this test, as the prussiate itself contains iron, and, if not carefully prepared, will give a blue precipitate when added to a mineral water, which contains an uncombined acid, even though iron be not present. This source of fallacy may be obviated, by ascertaining if the prussiate gives a blue tinge to diluted muriatic acid. If it do, it must be successively crystallized, till it does not give the blue colour with the acid; it may then be employed as an accurate test of the presence of iron.

Infusion of nutgalls is another very delicate test of iron. When this is added to a mineral water, containing a salt of iron with the protoxid, the fluid acquires a dark colour. This test is so delicate, that if one grain of the sulphate be dissolved in fifteen gallons of water, the solution will acquire a dark tinge on the addition of the infusion. In this case, however, the blackness does not appear for some days.

The colour produced by nutgalls, and the delicacy of it as a test, are affected by the presence of other substances. An earthy carbonate makes the test much more delicate; thus the infusion will detect a minute quantity of iron when dissolved in common well-water, which contains carbonate of lime, but will not indicate its presence, when dissolved in the same quantity of distilled water. An alkaline carbonate makes the colour dark violet; and, if sulphate of lime be present, the precipitate is at first white, and afterwards becomes black

54. *Copper* may be detected by evaporating the fluid to dryness, dissolving the residue in nitric acid, and adding ammonia to the solution. If this metal be present, it will acquire a blue colour.

Of the Methods employed in ascertaining the quantity of the different ingredients in Mineral Waters.

55. To ascertain the quantity of the *oxygen*, *nitrogen*, and *carbonic acid*, which water contains, the method already mentioned for ascertaining the nature of the elastic fluids must be followed. (36) The quantity of *oxygen* will be known by the use of the solution of the sulphuretted hydro-sulphuret of potassa, that of the *carbonic acid* by means of potassa having previously re-

moved the sulphuretted hydrogen by the addition of nitric acid to the water in the jar. If the elastic fluid contain *sulphurous acid*, its quantity will be ascertained by introducing the peroxid of lead; the amount of the absorption occasioned by the test for each will indicate its proportion, following the usual precautions of bringing the elastic fluids to the mean temperature and pressure.

56. The quantity of *sulphuretted hydrogen* cannot be found out by boiling the fluid, as the whole of the gas is not in this way expelled. The method recommended by Kirwan, is to fill three-fourths of a jar with the water, and invert it in a water trough; then throw up nitric oxide as long as red fumes appear. By this the sulphuretted hydrogen is decomposed, and the sulphur is deposited. This must be collected, and dried with a gentle heat. Each grain of it indicates 3 cubic inches of sulphuretted hydrogen.

The quantity of the saline ingredients in a mineral water may be ascertained either by finding its specific gravity, or by evaporation.

Mr. Kirwan has given an easy rule, by which we can ascertain the proportion of the saline matter by the specific gravity of the fluid. The specific gravity of distilled water must be subtracted from that of the mineral water, and the remainder must be multiplied by 1.4. The product is the quantity of saline matter, in a quantity of the mineral matter, equivalent to the number denoting the specific gravity of the distilled water. Thus, suppose the specific gravity of distilled water 1000, and that of the mineral water 1100, then $1100 - 1000 \times 1.4 = 140.00$ and $1000 : 140.00 :: 100 : 14.000$; the fluid therefore contains 14 per cent. of saline matter, supposing this free of its water of crystallization.

58. The other method of ascertaining the quantity of saline matter, is to evaporate slowly by heat, a certain quantity of the fluid to dryness, and expose the residue to a temperature sufficient to drive off the whole of the water; the residue indicates the quantity of saline ingredients.

59. *Sulphuric acid*. The quantity of sulphuric acid present, is ascertained by exposing to a red heat the precipitate given by baryta, (42.); 100 gr. of it are equivalent to 34 of real sulphuric acid.

60. *Boracic acid*. To find the quantity of boracic acid, add sulphuric acid to the precipitate given with the acetate of lead (44.) filter the fluid, and evaporate it to dryness. Dissolve the residue in alcohol, and again evaporate. The residue is boracic acid.

61. *Muriatic acid*. The quantity of muriatic acid is known by igniting the precipitate afforded by the salt of silver, (43.) 100 gr. are equivalent to 19 of muriatic acid.

62. *Lime*. The proportion of lime is ascertained by drying by a gentle heat the precipitate thrown down by oxalic acid (48.) 100 gr. = 44 lime. Or, the precipitate may be exposed to a high temperature, and then converted to sulphate by the addition of sulphuric acid. 100 gr. of this, after ignition, are equivalent to 41.5 lime.

63. *Magnesia* and *alumina*. By boiling in potassa the precipitate of magnesia and alumina thrown down by potassa, (56.) the magnesia will be left, and, after being washed and dried, must be weighed. By adding muriatic acid to the solution of the alumina, and then subcarbonate of potassa, the earth will be precipitated. It must be washed, exposed to a red heat, and weighed.

64. *Iron*. Different methods are recommended for ascertaining the quantity of iron or its oxides.

Some chemists have objected to the prussiate of potassa, as an accurate method of indicating the quantity of iron, as this salt itself contains iron, which is thrown down, and forms part of the precipitate. This source of error may be avoided, by ascertaining the quantity of iron that a given weight of the prussiate, carefully prepared, (53.) contains. This is done by exposing 100 grains of it to heat, in an open vessel, by which the oxide of the metal is obtained. In using this test then, to find out the quantity of iron in the mineral water, the quantity of prussiate employed must be ascertained, and the weight of the oxide, which this is known to contain, must be subtracted from the weight of the precipitate. 100 grains of the blue precipitate, dried by a gentle heat, according to Porret = 34.23 per oxide of the metal.

Another method of ascertaining the quantity of iron, is to bring the metal to a high state of oxidation, by exposing it for some time, in an open vessel, to a strong heat, in which condition it is insoluble in nitric acid. By pouring this acid on the residue, the oxide of iron is left, while the other substances are dissolved.

Of the Methods followed for ascertaining the state of Combination in which the different ingredients exist in Mineral Waters.

Very different opinions are entertained with respect to the state of combination in which the different ingredients exist in mineral waters. Some chemists suppose that they form binary compounds; others, on the contrary, imagine, that they are all more or less united with each other. Thus, if there be an acid, an alkali, and an earth together, it is not supposed that these are in the state of binary compounds, forming a salt of the alkali and another of the earth, but that they are combined so as to form a triple salt. The former is the more prevalent opinion. Some chemists assert also, that the salts procured by the evaporation of the fluid are those which exist in solution, while others maintain, that during the evaporation, new compounds are formed, so that we do not by this means procure those which the water in its natural state contains. This assertion is strengthened by the fact, that some salts exist together in solution, when much diluted, which decompose each other when the solution is concentrated. During the evaporation of a mineral water, therefore, new affinities may exert their influence, and salts, different from those which exist in the water, may be obtained. The experiments of Dr. Murray, immediately to be stated, tend to confirm this opinion.

According to the different opinions which are entertained, with respect to the state of combination of the ingredients, different methods have been recommended for ascertaining the compounds which mineral waters contain. The first of these is by the slow evaporation of the fluid.

By slowly evaporating the water, the different saline substances may be obtained separately. For this purpose, the evaporation is continued till a pellicle appear on the surface; the liquid is then allowed to cool slowly; by this the earthy carbonates will be deposited. After these are removed, by a farther evaporation and cooling, the sulphate of lime will be separated. The alkaline neutral salts, and the sulphate of magnesia, will be deposited after the next evaporation. The muriates of lime and magnesia will remain, and will be obtained by evaporation to dryness.

If the water contain carbonate of iron, it must, after having been evaporated to a certain extent, be exposed to the air, by which the iron passes to a higher state of oxidation, and is no longer soluble in the acid; it is therefore precipitated. The earthy carbonates are likewise separated by this means. After these have been deposited, the fluid may be evaporated to dryness, and a small quantity of water poured on the residue, by which some of the salts will be dissolved, and the others will be left. Sometimes the water is evaporated to dryness, and the residue is exposed to the air, by which the deliquescent salts, as the muriates of lime and magnesia, absorb moisture, and are dissolved. What is left undissolved, may be afterwards subjected to the action of water. Occasionally, after evaporating the fluid to dryness, the residue is subjected to the action of successive portions of water, by which the salts are taken up in the order of their solubility.

The different quantities of saline substances, thus obtained by these various methods, must be dissolved in separate portions of water, that by slow evaporation the salts which are mixed may be separated.

Another method of ascertaining the nature of the salts in mineral waters, is by means of alcohol. Some of the salts contained in mineral waters are soluble, while others are insoluble in alcohol. By a particular management, the different saline substances may be obtained, either in solution, or by deposition from the water.

When alcohol is added to water, containing saline matter, the attraction between the two fluids is so strong, that those salts which are insoluble in alcohol are separated from the water, and are deposited; thus, if a mineral water be mixed with an equal quantity of alcohol, sulphate of lime, if present, will be precipitated; if more alcohol be added to the fluid, the sulphate of soda will be separated; by adding another quantity of alcohol, muriate of soda will be thrown down. This method of employing alcohol in the analysis of mineral waters, was first pointed out by Boulduc.

Lavoisier has recommended another way of using alcohol. For this purpose the mineral water is to be evaporated to dryness, and eight parts of alcohol poured on the residue, by which some of the salts only will be dissolved. By adding alcohol, diluted with a little water, to the undissolved matter, another portion of the saline substance is taken up. In this way, by using alcohol of different specific gravities successively, the different saline compounds may be obtained separately; thus, when strong alcohol is poured on the residue of the evaporation of a mineral water, muriates of lime and magnesia, if present, will be dissolved. By diluting the next portion of alcohol with a little water, muriate of soda will be taken up, the carbonates and sulphates being left.

Occasionally these two methods of employing alcohol are joined; thus the mineral water is evaporated to dryness, and alcohol is poured on the residue, by which the muriates of lime and magnesia are dissolved. When the solution is completed, the fluid is filtered, and a small quantity of cold water is added to the undissolved matter, by which more of the saline substance is taken up. What remains is then boiled in a large quantity of water; by the application of the tests to the alcoholic and watery solutions, the different substances which they contain will be discovered.

It is supposed that considerable information may be derived with respect to the composition of mineral waters, from the knowledge of what are called incompatible salts. When a certain class of salts have been procured from a mineral water, it is generally inferred that other salts of a peculiar nature do not exist in it. Thus it is known that the alkaline carbonates decompose the sulphates and muriates of the earths and metals; these, therefore, it is supposed, are not contained in the same water. The same is the case with the alkaline sulphates, and the muriates of the earths, and with sulphate of magnesia and muriate of lime; these decomposing each other. Much reliance cannot however be placed in this conclusion, because salts which are known to decompose each other, when their solutions are not much diluted, exist together in solution, if a large quantity of the solvent be present, as has been fully proved by the analysis of different mineral waters.

By the different methods which have been pointed out, the different saline compounds of a mineral water may be procured; of course the mode to be followed must differ according to the ingredients, which by the use of the tests we have discovered in it. When the water contains a great variety of ingredients, the methods recommended require to be varied considerably before we can with certainty infer the presence of the different compounds. In addition to the evaporation of the fluid, and the use of alcohol, other substances must be employed to separate the saline bodies from each other, so that there may be no doubt of their nature. The various modes followed have been particularly illustrated by Kirwan, in his *Essay on Mineral Waters*.

65. *Alkaline nitrates*. To procure the alkaline nitrates, the water must first be freed of the sulphuric and muriatic acids, by means of acetate of baryta and acetate of silver, and then, after filtration, evaporated to dryness. Alcohol must be poured on the residue, which will dissolve part of it, and leave the nitrates probably mixed with acetate of lime. If this be present, the lime may be precipitated by dissolving the residue in water, and adding carbonate of magnesia to the solution. After this the fluid must be filtered, evaporated to dryness, and the residue digested in alcohol, by which the nitrates will be left. The alkali present may be known by the use of the tests. (46, 47.)

66. *Nitrate of lime*. To procure the nitrate of lime, the fluid must be evaporated, but the evaporation must be stopped before any deposition takes place. Alcohol is then to be added, which precipitates the sulphates. The fluid, after filtration, must be boiled, and the muriatic acid precipitated by acetate of silver. The fluid must be again filtered, evaporated to dryness, and the residue treated with alcohol. The solution then contains the acetates, and probably nitrate of lime. If present, the lime may be precipitated by oxalate of ammonia.

67. *Nitrate of magnesia*. Remove the sulphuric and muriatic acids, (65.) and evaporate to dryness. Digest the residue in alcohol, evaporate the solution to dryness, and dissolve what is left in water; the solution contains the acetates, and perhaps nitrate of magnesia. To this potassa must be added; if magnesia be present, a precipitate will fall. After this the solution must be

filtered, evaporated to dryness, and digested in alcohol; if any of it remain undissolved, it is nitrate of potassa, the nitric acid of which must have been set free from the magnesia.

68. *Alkaline carbonates.* The presence of the carbonates of the alkalies may be known, by the change effected on the vegetable colours. Should these changes not be permanent, we conclude that they are produced by ammonia. If permanent, then they are occasioned by the fixed alkalies. Whether potassa or soda, may be known by the proper tests. (46, 47.)

69. *The super-carbonates of the earths and iron* are detected by boiling the fluid, by which the excess of acid is expelled, and the carbonate precipitated. The substance precipitated may be known by dissolving the residue in muriatic acid, and applying the tests. (48, 50, 53.)

70. *Sulphates of potassa and soda.* To procure the sulphate of soda, evaporate the fluid to about one half of its bulk, and add lime-water, till all precipitation cease; this will throw down the earths, except lime. After this evaporate the fluid a little, and add alcohol, and then oxalic acid. After filtration add nitrate of lime. If a precipitate fall, then the solution contains sulphate of soda or potassa. These may be distinguished from each other by the tests of potassa, (46, 47.) or by adding to the solution acetate of baryta, which will throw down the sulphuric acid. Evaporate the fluid to dryness, and dissolve the residue in alcohol. Again evaporate to dryness, and expose the residue to the air. If it be acetate of potassa it will deliquesce, if acetate of soda it will effloresce.

71. *Sulphate of lime* may be detected by evaporating the water till a deposit be formed. If this be soluble in a large quantity of water, and the solution give a precipitate with baryta, not soluble in nitric acid, and also with oxalic acid, then it is sulphate of lime.

72. *Sulphate of magnesia* may be procured by the addition of hydro-sulphuret of strontia, which, if there be no free acid or sulphate of alumina present, gives a precipitate only with sulphate of magnesia. If sulphate of lime be present, a precipitate will be formed, but not for twenty-four hours after the addition of the hydro-sulphuret.

73. *Sulphate of iron.* When iron is in union with sulphuric acid, it is known by the tests of this metal detecting it in the water after it has been boiled. (53.)

74. *Muriate of soda.* Precipitate the sulphates by alcohol and nitrate of baryta. After filtration, decompose the nitrates and muriates by sulphuric acid, and boil the fluid. Again add alcohol and baryta, to precipitate the sulphates formed. The fluid then contains only alkaline nitrates and muriates. If the last be present, they must be decomposed by the addition of acetate of silver, by which acetates of the alkalies will be formed. These may be known by the methods recommended. (46, 47.)

75. *Muriate of lime.* Deprive the water of sulphates, by evaporation, and the addition of alcohol and nitrate of baryta; after filtration evaporate to dryness, and digest the residue in alcohol. Evaporate the solution, and subject the residue to the action of water. If the solution afford precipitates with oxalic acid, and with acetate of silver, then it contains muriatic acid and lime. But these may not be in union with each other, as the solution may contain magnesia or alumina. To ascertain if this be the case, add ammonia; if a precipitate fall, it contains magnesia. If the fluid give a precipitate on the addition of carbonate of lime, then it contains alumina, either of which may perhaps be in union with the muriatic acid. If neither of these earths be present, then the fluid contains muriate of lime. Suppose one or both present, to find out if the acid be in union with the lime, precipitate the earth by oxalic acid, filter, and subject the fluid to distillation, collecting the product in a cool receiver containing a little water. If this give a precipitate with nitrate of silver, then it contains muriatic acid, which was set free from the lime by the addition of the oxalic acid: or the solution may be evaporated to dryness, and exposed to a red heat for an hour; if it contain muriate of lime and magnesia in union with nitric acid, the latter salt will be decomposed. On exposing the residue to the air, the presence of muriate of lime will be known by its attracting moisture.

76. *Muriate of Magnesia.* Separate the sulphuric acid by baryta, filter, evaporate to dryness, and dissolve the residue in alcohol. Again evaporate and dissolve in water. If muriate of magnesia be present, it will be dissolved, and if carbonate of lime cause no precipitation, and if no precipitate be formed by evaporation and the addition of sulphuric acid and alcohol, then the fluid contains only muriatic acid and magnesia, in union with each other. But, along with these, there may be nitric acid, and lime or alumina, or both. We must therefore determine if, in this case, the muriatic acid and magnesia be in combination with each other. For this purpose, precipitate the lime by evaporation, and by the addition of sulphuric acid and alcohol, and drive off the acid with which it was in union, by boiling; then add oxalic acid, and the magnesia will be thrown down in the course of 24 hours. Subject the fluid to distillation, and ascertain if it contain muriatic acid, (43); if it does, then the fluid contained muriate of magnesia.

77. *Muriate of alumina.* If any free alkali be present, saturate it with nitric acid; then separate the sulphuric acid by nitrate of baryta. If the fluid after this give a precipitate with carbonate of lime, it contains muriate of alumina, or muriate of iron. Whether it be alumina or iron, or perhaps both, may be known by dissolving the precipitate in muriatic acid, and applying the tests of these substances, (50, 53.)

Of the Methods followed for ascertaining the quantities of the different compounds contained in Mineral Waters.

In ascertaining the quantities of the different compounds in mineral waters, the steps to be followed must, of course, vary in every different case, according to the substances contained in the water. A few examples will suffice to illustrate the methods employed.

In fixing the quantities of the different compounds, we may state them either in their crystallized condition, in which case they generally contain water; but it is better, if possible, to reduce them to dryness. This is done by exposing them to a red heat for some time, by which the whole of the water is driven off. Some of the salts which we procure undergo decomposition when subjected to a strong heat; such is the case with the carbonates and some others. We cannot, therefore, in this way, ascertain their quantity in the dry, or, as it is called, real state. We may do this, however, by decomposing them, ascertaining the quantity of the product, and finding how much of the decomposed salts is necessary to form these products.

78. *Nitrate of Potassa.* To ascertain the quantity of nitrate of potassa, suppose it exists in water, along with sulphates, and muriates of the alkalies, decompose these by the acetates of baryta and silver. After filtration, evaporate to dryness, and digest the residue in alcohol, which will dissolve the acetates formed, and will leave the nitrate.

79. *Nitrate of lime.* Suppose this contained in the water along with muriates of soda and lime, evaporate to dryness, and digest the residue in alcohol, which will dissolve the earthy salts, and leave the muriate of soda. Evaporate the alcoholic solution to dryness, and weigh the residue, after being dried; then dissolve it in water, and ascertain the quantity of muriatic acid, by precipitation with nitrate of silver, (43.); this will give the quantity of the muriate of lime, which, subtracted from the weight of the residue, leaves that of the nitrate of lime.

80 *Carbonates.* By boiling the fluid after it has been deprived of its sulphuretted hydrogen, (56.) the carbonates are precipitated, probably mixed with sulphate of lime. The carbonates may be that of lime, magnesia, alumina, or iron; the precipitate must therefore be digested in diluted muriatic acid, which will dissolve them all, except the alumina and the sulphate of lime. If any thing be left undissolved, it must be exposed to a red heat, and weighed; it is then to be boiled in the solution of subcarbonate of soda, and muriatic acid added, to saturate the alkali. By boiling the fluid, carbonate of lime, and alumina, if present, will be precipitated. Digest the precipitate in acetic acid, by which the alumina will be left; this, after being dried, will give the weight of the earth, and its weight, subtracted from that of the residue, the quantity of the sulphate ol lime.

81. *Carbonate of iron.* The muriatic solution may contain lime, magnesia, and iron. By the addition of ammonia, the iron and part of the magnesia will be precipitated. By digesting the precipitate in acetic acid, the magnesia will be dissolved, and the iron will be left. It must be dissolved in muriatic acid, and precipitated by the addition of sub-carbonate of soda. The precipitate, after boiling the fluid, must be washed, dried, and weighed, which gives the weight of the carbonate of iron.

82. *Carbonate of Lime.* The acetic solution of the magnesia must be mixed with the muriatic solution; to this, sulphuric acid must be added, and the fluid evaporated, and the sulphate of lime will be deposited. After being dried, it must be weighed, and its equivalent of carbonate of lime ascertained.

83. *Carbonate of Magnesia.* By the addition of subcarbonate of soda to the solution, the carbonate of magnesia will be precipitated. It must be dried and weighed The solution, however, still contains sulphate of lime, and carbonate of magnesia. It must therefore be evaporated to dryness, and the residue washed with water, which will dissolve the sulphate, and leave the carbonate. The weight of the latter of these must be added to that of the carbonate formerly procured. The solution of the sulphate must be evaporated to dryness, and the residue ignited, and the equivalent of carbonate of lime added to that already mentioned.

84. *Alkaline Sulphates.* The quantity of the alkaline sulphates may be ascertained, by freeing the water of the other sulphates, (70.) and then adding the solution of acetate of baryta. 100 grains of the precipitate are equivalent to 74.8 of dry sulphate of potassa, and to 61.2 of dry sulphate of soda.

85. *Sulphate of Lime.* Add nitric acid, to decompose the carbonates, boil the fluid, and add weak alcohol, the sulphate of lime will be precipitated. It must be then ignited and weighed.

86. *Sulphate of Magnesia.* If this be the only sulphate present, its quantity may be known by precipitating the sulphuric acid, and ascertaining the weight of the sulphate of baryta, 100 grains of which = 51 of the sulphate of magnesia. If sulphate of lime be likewise in solution, precipitate the lime by carbonate of magnesia, and weigh the precipitate; then throw down the sulphuric acid, and ascertain its quantity; subtract from it that which belongs to the lime, obtained by the former precipitation; the remainder gives the quantity of sulphate of magnesia, 100 of acid uniting with 50 of magnesia. If the fluid contain sulphate of magnesia and sulphate of soda, add soda, and the magnesia will be precipitated. Dry it and weigh it. 100 = 300 grains of dry sulphate of magnesia. If the fluid contain these three sulphates, add soda, by which the lime and magnesia will be precipitated. Dissolve the precipitate in diluted sulphuric acid, and evaporate to dryness; wash the residue with a little cold water, which will dissolve the sulphate of magnesia, and leave the sulphate of lime. Evaporate the solution, and weigh the residue; this is the weight of the sulphate of magnesia, the weight of the undissolved matter is that of the sulphate of lime. Should the water also contain sulphate of alumina, the precipitate given by the soda must be treated with acetic acid, which will dissolve the magnesia; the magnesia may then be precipitated by soda. If sulphate of iron be present, expose the fluid to the air for some days, and add alumina, the oxide of iron, and the sulphate of alumina are precipitated, and the sulphate of magnesia is left, and may be procured as above.

87. *Sulphate of iron.* Having ascertained, by boiling, that the iron is not in union with carbonic acid, precipitate the iron, (53.) and infer the quantity of sulphate.

88. *Muriates.* Suppose that the carbonates are thrown down by boiling, and that muriates of lime, magnesia, and alumina are present, add baryta, by which the whole of the three earths will be precipitated. Dissolve the precipitate in muriatic acid, and then ascertain, by the tests, (48, 50. 51,) the quantity of each earth, and infer that of the muriate of each.

100 lime = 196 dried muriate of lime.
100 magnesia = 238.3 dried muriate of magnesia.
100 alumina = 317.6 dried muriate of alumina.

89. When the sulphates are present with the muriates, the latter must be separated by evaporation to dryness, and treating the residue with alcohol, which will dissolve the muriates; then proceed as above. If sulphate of lime only be present, throw down the sulphuric acid by baryta, and ascertain its quantity, filter the fluid, and proceed as (88.) subtracting the quantity of the sulphate of lime from the lime obtained by precipitation, the remainder belongs to the muriatic acid.

90. When sulphates of lime and magnesia, and the muriates of soda, magnesia, and alumina are present, throw down the lime and alumina by carbonate of mag-

nesia, and ascertain the quantity of lime which will give that of the sulphate, (62.) Find out the quantity of sulphuric acid by baryta; subtract the quantity which we know was in union with the lime; the remainder will belong to the magnesia, and will shew the quantity of the sulphate of that earth.

91. To another portion of the water, add lime-water, which will throw down the magnesia and alumina; ascertain the proportions of these, (63.) that of the alumina will shew the quantity of muriate of alumina. (88) Subtract from the weight of magnesia that which we know to belong to sulphuric acid, the remainder will indicate the quantity of muriate of magnesia. By adding baryta, and then carbonic acid, to the fluid, the sulphuric acid and lime wlll be thrown down, and the quantity of muriate of soda may be ascertained by evaporation.

Such are the various methods which have been recommended for ascertaining the nature and quantity of the different compounds contained in mineral waters. It is doubtful, however, if, by these means, we arrive at the exact quantity of the different substances, and it is still more doubtful, if we really procure them in the state of combination in which they exist in the mineral water.

It has been already remarked, that little reliance can be placed in the knowledge derived from incompatible salts, as some salts which decompose each other, when their solutions are concentrated, exist together in solution, if a large quantity of the solvent be present.

This subject has been lately particularly investigated by Dr. Murray. From numerous experiments he has found, that salts, different from those known to be in solution, can be obtained by the evaporation of the solvent. This has induced him to call in question the accuracy of the modes of analysis explained, and to propose another method of determining the state of combination of the ingredients of mineral waters. See *Transactions of the Royal Society of Edinburgh*, vol. vii.

According to Dr. Murray, two views may be entertained with respect to the state of combination of saline substances dissolved in water. When we have two acids and two bases contained in this fluid, these may be united by the pure force of the affinity, and those substances between which the most powerful attraction is exerted, will be combined. Thus, suppose muriatic and sulphuric acids, and soda and lime, be dissolved in the same fluid, if the pure force of the affinity operate, the compounds formed will be sulphate of lime and muriate of soda. We know, however, that affinity is much influenced by external circumstances; when, therefore, any of these operate, compounds may be formed, different from those which the pure force of the affinity would generate. When the above mentioned substances are dissolved in a small quantity of water, the compounds stated are formed, but if the quantity of fluid be great, it is possible that it may, by its quantity, influence the affinity, and other compounds will be the result. When the quantity of fluid is small, or when we evaporate the fluid by which the cohesion is allowed to operate, we find invariably that the compounds existing in the water are those, between the particles of which the strongest cohesion is exerted. The reverse, it is probable, is the case, when the quantity of water is great, the quantity of the fluid causing the formation of substances, between the particles of which there is little power of cohesion, so that the most soluble salts are formed. When the above-mentioned substances, then, are dissolved in a large quantity of water, instead of sulphate of lime, and muriate of soda, we will have muriate of lime and sulphate of soda. The same it is supposed is the case, when carbonate of lime and muriate of soda are procured by evaporation, these salts having been formed by the decomposition of the carbonate of soda and muriate of lime, which were the salts that existed in the water, when a large quantity of the solvent was present. If carbonate of magnesia and muriate of soda be procured, the salts in solution were probably carbonate of soda and muriate of magnesia. In all mineral waters, the quantity of fluid is large in proportion to the saline ingredients; these, therefore, are probably united, so as to form the most soluble salts.

This view of the state of combination of the substances in solution in a large quantity of fluid, is supported by several facts. Thus, by the evaporation of some mineral waters, a quantity of a substance sparingly soluble, as of sulphate of lime, is obtained in greater quantity than we know water can hold in solution. It must therefore have been formed during the evaporation by the operation of new affinities. It usually happens also, that when this is the case, the deposition of the substance commences at a certain stage of the evaporation, and that, after the fluid is farther evaporated, the deposition ceases. At this point, then, it would appear that the substance deposited begins to be formed.

Another strong argument in favour of the opinion of Dr. Murray is, that different products are obtained from a mineral water according to the mode of analysis. Sea-water, for instance, by slow evaporation, affords muriate of soda, muriate of magnesia, and sulphate of magnesia. When the fluid is evaporated to dryness, and the residue is subjected to the action of alcohol, the products are, muriate of soda, muriate of magnesia, and sulphate of soda. It is likely, then, that during the evaporation of the fluid new affinities may exert their influence, so that salts, different from those which exist in solution, may be obtained.

Many mineral waters possess active properties, for which, however, we cannot account, on the known properties of the compounds discovered in them. Thus the Bath waters, according to the analysis by evaporation, contains in an English pint about 9 grains of sulphate of lime, 3.3 muriate of soda, 3 sulphate of soda, $\frac{8}{10}$ths of carbonate of lime, $\frac{1}{5}$th silica, and $\frac{1}{70}$th oxide of iron. These are either so inert, or in so small quantity, as to be incapable of producing any effects on the living system. According to Dr. Murray, the true component parts of the Bath water are very different. It contains muriate of lime, a substance possessed of considerable power, along with muriate of iron. The quantity of muriate of lime, equivalent to 3.3 of muriate of soda, is 3.1. A pint, therefore, of the Bath water, if the views of Murray be correct, contains 3.1 gr. of this active agent. If this be the case, we can perhaps account for its medicinal properties.

The opinions entertained by Dr. Murray, as just explained, afford another method of analysing mineral waters.

In analysing a mineral water, according to the mode recommended by Murray, we must first, by the use of the various tests already described, ascertain the different substances which it contains. We then infer that these exist in it in a state of combination, so as to form the most soluble salts.

This method of ascertaining the quantity of saline compounds in water, was previously employed by Dr.

Marcet, in his analysis of the water of the Dead Sea, published in the *Philosophical Transactions* for 1807. Dr. Marcet does not, however, state, that he supposed the ingredients were so combined as to form the most soluble salts.

Dr. Murray has given the following formula, which is applicable to almost all mineral waters.

The four classes of mineral waters, the acidulous, the sulphureous, the chalybeate, and the saline, may all be reduced under the last. By the application of caloric, the gaseous fluids are driven off from the two first, and the iron may be precipitated from the third by its proper test. The substances left after this are the same as those contained in saline mineral waters.

The substances which usually exist in saline mineral waters, are carbonic, sulphuric, and muriatic acids, with soda, lime, and magnesia. Suppose that in the water to be analysed all of these have been detected, the fluid must be evaporated, stopping the evaporation before there is any deposition from it. Muriate of baryta is then to be added, as long as any precipitate falls, carefully avoiding adding an excess. If the precipitate be soluble with effervescence in muriatic acid, it is carbonate of baryta. The weight of this gives that of the carbonic acid 100 gr. = 22 of acid. If the precipitate do not effervesce with muriatic acid, it is sulphate of baryta, 100 gr. of which = 34 of sulphuric acid. If the precipitate be partially soluble in muriatic acid, it contains both carbonate and sulphate of baryta; the proportions of each of which may be known, by weighing the precipitate, washing it with muriatic acid, and drying the residue. The weight of this gives that of the sulphate, the loss that of the carbonate of baryta. By this means the carbonic and sulphuric acids are removed, and the whole of the salts are converted to muriates. Oxalate of ammonia is next to be added to the filtered fluid. Oxalate of lime is precipitated, which, after being exposed to a strong heat, must be converted into sulphate. (62.) 100 g. = 41.5 of lime.

The filtered fluid is afterwards to be heated to about 100°, and reduced a little by evaporation. A solution of carbonate of ammonia is then to be added to it, and immediately afterwards a solution of phosphate of ammonia, continuing the addition of both as long as there is any precipitation, taking care to leave an excess of ammonia. By the addition of these substances, one part of the ammonia neutralises the muriatic acid of the muriate of magnesia, the other portion combines with the phosphoric acid and the magnesia, and forms the triple phosphate of magnesia and ammonia which is precipitated. By exposing this to a red heat for an hour it is converted into phosphate of magnesia, 100 gr. of which = 40 magnesia. After this the fluid contains muriate of soda, perhaps with muriate of ammonia. To procure the former it must be evaporated to dryness, and the residue exposed to a high temperature, 100 = 53.3 soda.

The muriatic acid in the muriate of soda obtained may be either greater or less than what was contained originally in the fluid; part of the soda may have been disengaged from the other acids, and have combined with the muriatic acid of the muriate of baryta, used in the precipitation of the sulphuric and carbonic acids. If this be the case, the acid in the muriate of soda procured will be greater than what existed in the water; or the soda may be in less quantity than could neutralize the whole of the muriatic acid, part of this acid having been combined with the other bases. If this be the case, the acid set free during the addition of the ammoniacal salts would be contained in the residue of the evaporation in union with ammonia, but would be volatilized by the heat, the muriatic acid in the muriate of soda would therefore be less than the water originally contained. Though the quantity of muriate of soda procured, therefore, gives the real quantity of the soda, yet it does not afford the proportion of the muriatic acid. This may be discovered, by combining by calculation the bases with the acids, taking the quantity of muriatic acid in the muriate of soda, and thus we will find whether there be a deficiency or redundance of muriatic acid. By subtracting the surplus from what exists in the muriate of soda, or by adding the deficiency to it, we arrive at the quantity of the muriatic acid. This method is, however, liable to fallacy. It is better, therefore, to take a separate portion of the water, evaporated to the proper strength, and remove the carbonic and sulphuric acids by means of nitrate of baryta, and then add nitrate of silver to it, by which we ascertain the quantity of muriatic acid. (61).

By these different steps we ascertain the quantity of the different ingredients. We must next ascertain the state of combination in which they existed. This is done, by supposing that the ingredients were so united as to form the most soluble salts. Should other substances, besides these mentioned, be supposed to exist in the water, as potassa or alumina, they must be detected by their proper test, and their proportions ascertained. These, it is supposed, are likewise so combined, as to form with the acids the most soluble compounds. Thus, in his experiments on sea water, Dr. Murray found that a pint of this fluid contained,

Lime	2.9
Magnesia	14.8
Soda	96.3
Sulphuric acid . . .	14.4
Muriatic acid . . .	97.7
	226.1

These, he inferred, existed in the water in the state of muriate of soda, muriate of lime, muriate of magnesia, and sulphate of soda. The quantity of sulphate of soda equivalent to 14.4, of sulphuric acid is 25.6; the remainder of the soda 85.1 is united with 74.2 of muriatic acid, to form 159.3 of muriate of soda. The quantity of muriate of lime, equivalent to 2.9 of lime, is 5.7. The 14.8 of magnesia is combined with the remainder of the muriatic acid, to form 35.5 muriate of magnesia. The saline contents, then, according to this way of determining the compounds, are

Muriate of soda . .	159.3
Muriate of magnesia	95.5
Muriate of lime . .	5.7
Sulphate of soda . .	25.6
	226.1

In the same way, having ascertained the proportions of the different ingredients in any mineral water, the quantities of the compounds which they form may be ascertained.

If this view of the constitution of mineral waters be correct, the component parts of those analysed will be very different from what has been stated in the foregoing Table, these having been ascertained by the evaporation of the fluid, and by the other methods usually followed in the analysis of mineral waters. Thus those which have yielded sulphate of lime and muriate of soda, it is inferred, contain muriate of lime and sulphate of soda, the two former having been generated during the evaporation by the decomposition of the latter. The quantities of the substances contained in the water may be ascertained, by finding the equivalents of the different compounds. Thus 100 of sulphate of lime are equivalent to 81.5 of muriate of lime; and 100 muriate of soda are equivalent to 122 sulphate of soda.*

The mode of analysing mineral waters recommended by Dr. Murray, is one attended with much less labour, and, it is probable, leads to results at least as accurate, if not more so, than those obtained by any of the other methods of analysis. A strong argument in its favour, is its detecting in mineral waters substances which act powerfully on the animal system, and thus enabling us to account for the medicinal effects of some of them, which cannot be done by the other modes of analysis.

MINERALOGY.

Mineralogy is that branch of natural history which makes us acquainted with all the properties and relations of minerals. It is divided, by Werner, into several branches, or doctrines, viz.: Oryctognosy, geognosy, mineralogical chemistry, mineralogical geography, and economical mineralogy. Oryctognosy, (or mineralogy, commonly so called,) arranges and describes simple minerals, according to their external characters; geognosy makes us acquainted with the structure, relative position, materials, and mode of formation of mountain rocks, or those mineral masses of which the crust of the earth is composed; mineralogical chemistry enumerates the various chemical properties and relations of minerals; mineralogical geography delineates the geographical distribution of simple and compound minerals over the face of the earth; and economical mineralogy teaches us the various uses of minerals, whether simple or compound.

In the general view of mineralogy adapted to the nature of an Encyclopædia, we cannot use this arrangement of Werner's. We shall consider mineralogy under two heads; viz. Geognosy and Oryctognosy; and view them in such a manner as to include the most important details which belong to the doctrines of chemical, geographical, and economical mineralogy.

GEOGNOSY.

CHAP. I. *History.*

This important branch of natural history makes us acquainted with the structure, relative position, materials, and mode of formation of the mineral masses of which the crust of the earth is composed. The term *geognosy* is derived from the Greek words γη, *the earth*, and γνωσις, *knowledge*. It has been confounded with *orology*, which instructs us regarding the physiognomy of mountains; with *geogony*, which is purely hypothetical, consisting of very abstract speculations regarding the original formation of the earth; also with *geology*, which, however, has a more extensive signification, for the word λογος comprehends the whole science, or rationale of any subject; and therefore geognosy is only a branch of geology. Geology, indeed, according to Werner, comprehends not only *geognosy*, but also *geography*, *hydrography*, *meteorology*, and *geogony*.

The speculative part of geognosy engaged the attention of mankind at a very early period; for we find that the priests of Egypt maintained the aqueous origin of the globe. From Egypt science passed into Greece; and we learn that Thales, one of the most distinguished of the Grecian philosophers, taught the Neptunian view of the origin and formation of the earth, which he had become acquainted with during his residence in Egypt. Zeno, another learned Greek philosopher, maintained that fire was the *prima materia*, and that the earth was formed from the igneous element. But it would be vain to attempt an account of the various fanciful speculations on the formation of the earth, proposed by ancient authors. These afford us no satisfactory information, in regard to the materials and structure of the crust of the earth. Agricola, in Saxony, and that remarkable man Bernard de Palissy, in France, were the first observers who proposed rational opinions respecting the formation of minerals. But the universal devotion to idle, useless, and pernicious scholastic discussions, so prevalent at that time, and which continued for a long succeeding period, occasioned an almost total neglect of their observations and opinions. In the year 1740, De Maillet, who had resided long in Egypt, and who adopted the opinions of the ancient philosophers of that country, where he himself had witnessed how the waters, by the deposition of earthy matter, contributed to the magnitude of the earth, attempted a general explanation of the formation of the globe. In his curious work, entitled *Telliamed*, (his own name reversed,) he maintains, that our globe is composed of strata, which have been successively deposited over each other by the sea, which gradually retired and uncovered the present continents. This opinion was adopted by Linnæus, in his amusing tract, entitled *De Telluris habitabilis incremento;* and Buffon, in his splendid vision of the formation of the earth, inclines partially to this hypothesis; for he considers the superficial strata of the globe as having been formed from water. But all these speculations rested on a very insecure basis; because the mineralogy of no tract of country had hitherto been accurately and scientifically examined. It was therefore idle to attempt to speculate on the formation of the earth with any prospect of success, when we were ignorant of the materials of which it is composed, and of their structures and modes of arrangement.

Tilias, a Swede, was one of the first naturalists who was aware of the utility and importance of such descriptions; and, in the year 1750, he published several topographical descriptions, illustrative of districts in Sweden. This example was speedily followed, and, in the year 1756, Lehman, a German miner, published his celebrated work on secondary, or flœtz rocks, in which the distinction into primitive and secondary mountains is first proposed. Wallerius, professor of mineralogy at Upsal, by the publication of his system of mineralogy

* For finding these numbers, the scale of equivalents of Wollaston is admirably adapted, as by it a great deal of calculation is saved.

in 1778, and Gerhard, in his elementary work on minerals, made us acquainted with the geognostical situation of many minerals. But of all the works of that period, the most important was the physical geography of Bergman, in which we find collected and disposed, in a luminous order, all the facts and observations hitherto published, in regard to the strata of the earth, and to mineral veins. Travellers now made the investigation of the strata of countries an object of particular attention. Pallas, who was employed by the Russian government, in examining the natural productions of that vast empire, although the state of mineralogy at that period, and the rapidity of his journeys, prevented minute investigations, made many important geognostical observations, and was the first who investigated with care the numerous and striking fossil remains of elephants, rhinoceroses, and other genera of the torrid zone, found buried under the icy soil of Siberia.

Guettard and Monnet, in France, supported by public aid, and assisted by many naturalists, undertook the mineralogical description of France. Several parts of this work were published, but the facts were not well arranged or connected. Lavoisier, the celebrated chemist, co-operated in this mineralogical history of France, and published several beautiful descriptive memoirs. Other naturalists gave descriptions of districts in France; Gensane published that of Languedoc; Faujas that of Dauphiny, and made us acquainted with the volcanoes of Vivarais; Desmarest had already described the volcanoes of Auvergne; Palassou, in his essay on the Pyrenees, explained the structure of that great range of mountains, and was the first to state the important fact, that the direction of the strata is parallel with that of the chain. But, of all the works published at this period, (1779,) the most important, and that which contributed in the most eminent degree to the advancement of geognosy, was the first volume of the travels of the celebrated Saussure. It contains many interesting mineralogical facts, and numerous important geological observations. The succeeding volumes of this work of Saussure's abound in valuable facts and beautiful views of nature, and characterise him as one of the most profound and successful of geologists. J. A. Deluc, also a native of Geneva, and cotemporary of Saussure, was an active enquirer, who added several important facts and views to geology. Some years before the appearance of the works of Saussure and of Deluc, the celebrated Werner was appointed professor of mineralogy at Freyberg in Saxony. This remarkable man, by his numerous observations, and profound views of nature, created a new æra in mineralogy. He was the first to point out and explain the true *mode* of investigating geognostical phenomena; he first arranged and developed the principal structures that occur in the crust of the earth, and explained and enumerated the various relations of mountain-rocks, beds, and veins, and of the fossil organic remains contained in strata of different kinds.

Unfortunately for science, he published but little, so that his discoveries, arrangements, and views, were principally made known by the writings of his numerous pupils. These were of all countries, from the shores of the Black Sea to the extremity of Norway; and his fame and views were carried to the Americas, and principally by his own pupils. Indeed most of the distinguished mineralogists of the present age have proceeded from the celebrated school of Freyberg. Mohs, Charpentier, Buch, Raumer, Freisleben, Humboldt, Steffens, Engelhart, Esmark, d'Andrada, Brocchi, De la Rio, and many others, might be mentioned as pupils of this great and profound naturalist. Whilst Werner, by his prelections, and the activity, zeal, and skill of his pupils, was advancing geognosy in Germany, and in many other countries, we find that Patrin, Delametherie, Raymond, and others in France, were adding to our knowledge of the structure and composition of the earth. But of all French geologists, the most distinguished was Dolomieu. He was one of the first naturalists who examined, in a satisfactory manner, the nature of active volcanoes, and his writings and views, in this department of geognosy, may be considered as having led the way to the investigations and views of Spallanzani, Fortis, Faujas, Breislac, and Cordier. But he did not confine his attention solely to the study of volcanic districts, for he has left several interesting memoirs on mineral formations. In France, the study of petrifactions, or fossil organic remains, has materially contributed to the advancement of geognosy. The previous views of Werner, on this subject, the discoveries and observations of Hunter, Blumenbach, Schlottheim, and others, paved the way for the more extended and brilliant investigations of Cuvier.

Whilst geognosy was advancing in other countries, it was until lately but little attended to in Great Britain. The publication of the theory of Burnet, in 1681, and the speculations of Robinson, in 1699, amused, without communicating any real information. Woodward's Essay on the Natural History of the Earth, published in 1702, was the first which contained any facts of importance, and the lectures and discourses on earthquakes, by Robert Hooke, in 1705, the physico-theological discourses of Ray, in 1713, and the new theory of the earth of Whiston, in 1722, were principally of a speculative nature. The inquiry into the original state and formation of the earth, by John Whitehurst, published in 1778, although principally theoretical, contained good observations on the structure of some districts in England. James Douglass, in 1785, published a dissertation on the antiquity of the earth, in which certain fossil organic remains are particularly considered. About this time, Dr. Hutton, of Edinburgh, published, in the *Philosophical Transactions* of the Royal Society of Edinburgh, a striking essay on the theory of the earth. But this work, like all those of a merely speculative nature, did not afford any beneficial results to geognosy; indeed it remained nearly unnoticed, except in some controversial tracts, by Mr. Kirwan, until it was reproduced to the public by Professor Playfair, in his interesting work, entitled "*Illustrations of the Huttonian Theory*," published in 1806. In 1801, Professor Jameson published, in two volumes quarto, the results of his observations on the geognosy of the Hebrides, Orkney, and Shetland Islands, in a work entitled *Mineralogy of the Scottish Isles*. This was the first extensive topographical geognostical work that had appeared in Britain. In 1808, the same naturalist published his *Elements of Geognosy*, in which the structure and materials of the earth are scientifically considered. About this time the Wernerian Society of Edinburgh, and Geological Society of London, were established; two associations which have eminently contributed to the advancement of geognosy. Other geological societies have since been established in different parts of Great Britain; and the science is now extensively and actively cultivated in every civilized country in Europe.

CHAP. II.

Description of the Surface of the Earth.

When we take a very general view of the earth, it appears as a globular solid mass, whose surface is diversified by numerous eminences, of various magnitudes and forms.

2. Experience teaches us, that the great fossil masses, of which the solid body of the earth is composed, when viewed on the great scale, have a *tabular form*, and are consequently more extended in length and breadth than in thickness.

We also find that these masses or rocks are composed of different minerals, in various states of aggregation. Of these the earthy form the greater portion of the earth, while the saline, inflammable, and metallic minerals occur in very various and remarkable relations, in the greater and more prevalent masses, yet always in such a proportion, that when viewed on the great scale, they do not contribute to the formation of the figure of the earth or its surface.

3. When we examine the surface of the globe more particularly, a certain locality of its inequalities is to be observed. Thus the most considerable inequalities, those, namely, which present the most frequent and the deepest sections and fissures, are always found in the more elevated regions; while in the lower places we observe very few, and by no means such special elevations and depressions. We further observe, that the masses of which the higher and lower parts of the earth are composed, are by no means of the same nature. The elevated, rugged, and very uneven places, are mostly composed of rocky masses, which present to the eye rough, bare, and fissured cliffs, mural precipices, and even entire rocky valleys. On the other hand, in the lower parts of the earth, we find in general earthy masses, as clay, loam, sand, and rolled stones; but neither cliffs nor rocky valleys, and only single blocks of the materials of the more elevated places.

4. There is still another general and very interesting observation to be made, namely, that the remains of organic beings more or less changed, (what are denominated *petrifactions*,) are found embedded in these rocks. These remarkable bodies are generally found in the middle and lower heights of the earth. In the middle heights they are still very rare; but they increase in variety and number, as we approach the lower places, and are at length accumulated in immense quantities in the lowest parts. We also observe, that the organic remains found in the middle heights are totally changed into stone; but the lower the situation, the more these bodies appear unaltered, or approach to their original state. It is also observed, that the higher places afford different genera and species of petrifactions from those found in the lower; and although we are able to show the originals of some of those petrifactions which are found in lower places, as proofs of their origin, those found in the middle heights belong to species that are unknown to us. Lastly, we may remark, that in all the situations already mentioned, that is, from the middle to the lowest heights, but particularly in the latter, there are some rocks in which few or no traces of such organic remains have ever been found; although, from the local situation of the rocks, we might as readily expect to find petrifactions in them, as in other rocks of the same relative height.

5. When we examine the surface of the earth more particularly, we find that the special inequalities are included in others more general; that these general inequalities are again contained in others still more general; and that at length the whole are included in the most general. These inequalities may be divided into five classes or degrees. The first contains the most general inequalities; these are *the bottom of the sea*, and *the dry land*. The second comprehends what may be termed *low country* and *high country*. The third, which is more special, comprehends *mountain groups*. The fourth, which is still more particular, comprehends *mountain chains* and *valleys*. The fifth and last, which is the most special, comprehends *single mountains*, and the *ravines* or valleys between them. We have thus a most beautiful series, from the single mountain and the ravine to the great fabric of the high country; and still further to the most general division of the inequalities of the earth's surface, the dry land, and the bottom of the sea.

First Degree.

Dry Land. Bottom of the Sea.

Second Degree.

High Land. Low Land.

Third Degree.

Alpine Land. Plain.

The mountainous and hilly land make the transition from the Alpine land to the plain.

Fourth Degree.

Mountain Range. Valley.

Fifth Degree.

Mountain. Ravine.

We shall now consider each of these inequalities in detail.

6. In regard to the *bottom of the sea*, we may at present remark, that it is diversified by many inequalities; which, however, are not so special as those on the surface of the dry land.

The ocean covers about three-fifths of the whole earth, so that there is but a comparatively small portion of it elevated above the surface of the water. Even this does not form a connected whole; on the contrary, it is divided into a number of detached masses, to which geographers have given different names: the larger are denominated *continents*, the smaller, *islands*.

The geographic division of the earth into continents is not quite correct. Thus Europe and Asia, which form but one continent, are by geographers divided into two; whereas America, which forms two very distinct continents, having their natural boundary at the Isthmus of Darien, is considered as one. Europe and Asia should therefore be considered as forming one continent, and America two. Africa, on the contrary, is well characterised as a distinct continent.

The great inequality of the distribution of the land, which rises above the surface of the ocean, deserves attention. If we conceive the earth divided into two equal parts by the equator, we shall find a most striking difference in the proportion of land on its north and south sides: the southern half is almost entirely composed of water; but in the northern, the greater portion is land. The proportion of land on the north and south sides of the equator, is as $\frac{2}{3}$ to $\frac{1}{3}$. It has been also observed, that if the earth be divided by a meridian line, the proportion of land and water on opposite sides is strikingly different; there being always a preponderance of water in the one side, and land on the other.

This great accumulation of land in the northern half of the globe, suggested to some speculators the idea of the existence of a southern continent; as they conceived it to be impossible that the equipoise of the earth could otherwise remain undisturbed. The illustrious Cook, however, has shown, that even beyond 71° S. latitude, there is no appearance of a continent; and that these dreary regions of water and ice are only diversified by a few islands.*

7. The most general inequalities observable on the surface of the *dry land* are, as we have already observed, *high land* and *low land*. By the first, we understand a lofty, uneven, and widely extended mass of land: by the second, a great and widely extended low and flat country.

In Europe, we find but two high lands and one low land. The one is the great European or Southern; the other the Scandinavian or Northern. The one has its middle point in Switzerland, in the Tyrol, and the Alps of Savoy. Hence it passes through three-fourths of France; traverses the whole of Portugal and Spain; includes nearly two-thirds of Germany; passes through the greater part of Italy; and also part of Hungary and Turkey; and terminates on the borders of the Black Sea. The course of this high land determines that of the great low land. Saxony lies nearly on the border of this low land or plain. It passes through the north part of Saxony, to the East or Baltic Sea. It also passes by the foot of the Hartz Mountains; through the upper part of Westphalia; and further, through the whole of Holland, the Netherlands, and a small part of France; it even reaches the east coast of this island. It extends very considerably towards the north, including in its course, Prussia, Poland, and nearly all Russia in Europe; and reaches to the Uralian Mountains, including the greater part of Moldavia.

The other high land rises in Norway and Sweden; comprehends a portion of Russia; and extends, with some interruption, to the Uralian mountains.

High and low lands might also be pointed out in the other continents.

8. Every high land is composed of what may be termed *alpine*, *mountainous*, and *hilly* land; and sometimes of small plains. The low land, on the contrary, consists principally of *plains*; but we find in it, also, sometimes mountainous and hilly land, and, very rarely, small mountain groups. Here the constituent parts are directly reversed; in high land, the alpine country forms the predominating feature, but in low land the plain is the characteristic appearance.

9. *Alpine land* is composed of *mountain groups*, or groups of mountains. Each mountain group consists of a number of inequalities, which are denominated *mountains*; and these are arranged into series, forming what are called *mountain chains*, or chains of mountains. A number of these chains, when joined together in a determinate manner, form a *mountain group*. Mountain groups are thus excellently distinguished from the other constituent parts of the high land.

It is of much importance to be able to discriminate a mountain group from others on which it may border, or with which it may be surrounded. For facilitating this discrimination it may be remarked, that mountain groups are highest in the middle, and usually become gradually lower and smaller towards the extremities; and that each individual group has a particular direction.

Mountain groups are sometimes separated from each other by plains; sometimes by valleys; frequently by mountainous or hilly country.

10. *Mountainous land* is composed of mountains that

* The *dry land*, according to some French geographers, is divided into *three worlds*, the *Old World*, *New World*, and *Maritime World*; and these are subdivided into eight divisions or parts.

The *old world*, in the eastern hemisphere, extends from south-west to north-east, and comprehends two continents, viz. Africa and Asia, and Europe.

The *new world*, in the western hemisphere, extends from north to south, and is composed of *two* continents, North and South America.

To the south-east of Asia, there is a mass of land nearly as large as Europe. It is Notasia, or New Holland. It is surrounded with many islands of great extent, and with smaller groups of islands, that extend to the vicinity of the New World. This is named the *maritime world*.

The maritime world is composed of three distinct parts: 1. *Australasia*, which includes New Holland, and the great islands that lie to the east of it. 2. The great archipelago of islands to the south of Asia, named the *Archipelago of Notasia*. The third, which is named *Polynesia*, includes the islands scattered through the great Pacific Ocean.

Those islands situated near continents, are considered as belonging to them. Thus the British Isles belong to Europe; those of Japan, to Asia; the West India Islands to America; Madagascar to Africa. But there are other small islands situated in the middle of the Great Ocean, and which cannot be referred to any of the preceding divisions. These may be named *Pelagien*, and belong to the oceans in which they are situated.

Great islands, like continents, have their high chains of mountains, rivers, lakes, forests, deserts, and large animals.

In the island of Sumatra, which is only a secondary one in point of magnitude in the *Archipelago of Notasia*, we meet with the elephant, rhinoceros, and hippopotamus; but the species of animals are often different from those of the neighbouring continents. Thus the rhinoceros of Sumatra is different from that of Asia and Africa. Madagascar produces that singular species of sloth named *ai*, and the different species of makis, which we do not meet with in Africa or elsewhere. The inhabitants of Van Dieman's Land are very different from those of New Holland; and the greater number of mammiferous animals and reptiles are specifically different from those met with on the neighbouring continent. The dog, which is so much prized, and so generally distributed, is a stranger to them, while it is met with very generally in New Holland. Islands of a moderate extent have no great animals, and their rivers are smaller than those of the first magnitude.

The smallest isles are simply rocks, without rivulets, or even springs. Their precipitous cliffs and caves are sometimes beautifully ornamented with madrepores, and with fuci of various beautiful colours and elegant forms. Their summits are inhabited by pelicans, cormorants, albatrosses, frigate birds, and a host of other marine birds; and during tempests, they are lashed by a furious and highly phosphoric ocean.

As these three worlds are narrow towards the south, and broad towards the north, it follows, that the *northern hemisphere* contains the larger portion of land, and may be called the *terrestrial hemisphere*. The *southern hemisphere*, which is very much covered with the waters of the ocean, may be named the *maritime hemisphere*.

are aggravated into chains; but these chains not connected together by a central or high mountain chain. Hence it never forms groups. It is lower than alpine land; and is often intersected, which is never the case with alpine land.

11. The third constituent part of high land, namely, *Hilly land*, is much lower than mountainous country, and consists of gentle, rounded, waved-like elevations. These are sometimes arranged into groups.

We have thus a complete series, from the most elevated and complete alpine country, through the mountainous and hilly, to the low country.

12. In regard to the local situation of the constituent parts of high land, we may remark, that alpine land forms its principal constituent part, and that this is distinguished from mountainous and hilly land, not only by its frequency, but also by height, and its usually occupying the middle part of the high land; whereas its borders are marked by mountainous and hilly land; thus forming the transition to what is termed low land.

13. The fourth constituent part of high land is *plains*. These are small, isolated, and rare; and hence form but unimportant features in the general aspect of high land.

14. *Low land* differs very much in its characters from high land. It is principally composed of plains, and sometimes contains flat hilly country, chiefly where it borders on alpine country. Very rarely small mountain groups occur in it, and these always occupy its middle part.

15. As alpine land is very varied in its aspect, it will be proper now to consider its different parts somewhat in detail. When a mountain group, or alpine land, is viewed as a whole, it appears highest in the middle; and this highest part extends through the whole group without being intersected. This elevated portion is by geographers denominated the *high mountain chain*, and is one of the most remarkable parts of a mountain group, because nature appears to have arranged all the other parts as subordinate to it. It is the water-shed for the whole of the neighbouring country, and is parallel to the length of the group; hence the extremities of the group are at the same time that of the high mountain chain.

All the other parts of the mountain group decline on both sides from the high mountain chain; and the inclined plains thus formed, are denominated the *fall* or *acclivity* of the group. The inclination of the acclivity varies from 2° to 6°; that of the northern declivity of the Pyrenees is from 3° to 4°; that of the southern acclivity of the Alps, from the line formed by the colossal summits of Mont Blanc, Mont Cerven, and Mont Rose, and of which the general height is 3500 metres, to the plains of Piedmont and Lombardy, is 3¾°. But as such a general inclination is made up of many particular inclinations, on account of the inequalities of the acclivity, we must, before we reach the summit, ascend and descend acclivities much more considerable than that we have just mentioned. The two acclivities of a group have rarely the same degree of inclination; on the contrary, one is generally shorter and steeper than the other. Thus, the northern acclivity of the Erzgeberge is long and gentle, while the southern is rapid and short. In the Pyrenees, the northern acclivity is more extensive and steeper than the southern. The western acclivity of the Andes is shorter and steeper than the eastern. The lower part of the group, that which borders on mountainous and hilly country, is denominated its *foot*. When a portion of it extends far into low country, it is denominated a *mountain arm*. We sometimes meet with small plains on the acclivity of the group, and these may be denominated *mountain plains*, to distinguish them from those observed in low country. Very considerable heights sometimes occur in the acclivity of the group, but these seldom reach the height of the high mountain chain.

The concavities, or hollows, in a mountain group, are denominated *valleys*. The valleys shoot from the high mountain chain, intersect the acclivity of the mountain group, and terminate at its foot. The valleys divide the mountain chains from each other; and by this division nature has formed all the varieties of structure observed in mountain groups.

The lateral chains shoot on both sides from the high mountain chain towards the foot of the group. Of these lateral chains some are more considerable than others: the most considerable, that which rises from the middle of the high mountain chain, and reaches to the foot of the group, is denominated the *principal mountain chain*; the other chains either shoot from the foot of the group towards the principal mountain chain, but never reach the high mountain chain; or they proceed from the high mountain chain, but never reach the foot of the group. The principal mountain chain of one group cannot join with the principal mountain chain of another, nor can the high mountain chain of one group join with that of another. The summit of a mountain chain is denominated its *ridge*, and that of the highest mountain chain the *highest mountain ridge*.

We have nearly the same circumstances to attend to in regard to valleys as to mountain chains; only there is here nothing analogous to the high or middle mountain chain. There are two chief kinds of valleys, namely, the *principal*, and *lateral* or *subordinate*. The *principal* valleys stretch uninterrupted from the high mountain chain to the foot of the mountain group, and those only are the principal valleys that reach this point; all the others are *subordinate* or *lateral* valleys. These either extend from a mountain chain to a principal valley, or begin from a lateral chain, or the principal mountain chain, and terminate at the foot of the mountain group. Mountain chains are divided into *mountains* by small valleys or ravines. In the valleys of mountain groups, we have always rivers or streams, but in those of mountain chains, there are either none, or small rivulets. The bottom of such valleys has usually a very rapid ascent; they are not deep, and are neither so wide nor so extensive as true valleys, or those formed of ranges of mountains.

16. The different parts of individual mountains must also be described. Almost every mountain has a *foot*, *acclivity*, and *summit*. By the first, we understand the lowest and flattest part of a mountain. It sometimes extends to a considerable distance, and then rises under an angle of 8° or 10°; when it is less extensive, or has a smaller base, it rises under a somewhat greater angle, but never greatly exceeds 10°. The mountains in wide valleys have generally a considerable foot, but those in narrow valleys are less in extent. Sometimes, as in mountains having a *mural ascent*, there is no foot.

The Acclivity or Ascent.—By this we understand the space contained between the foot and the summit of a mountain. It is usually the steepest and most considerable part of it. Its inclination is less or more than 30°, and on this depends the greater or less covering of soil. Upon an acclivity of 30° and upwards, we find a good cover of soil; at 45°, however, the acclivity is too great to admit the growth of trees. Sometimes the acclivity is perpendicular, forming mural precipices; and it is either mural on one, two, or all sides, or in single spots. Granite, porphyry, and sandstone, afford examples of such acclivities. Humboldt remarks, in regard to acclivities in general, that they are to be reckoned considerable when their angle is 7° or 8°, which is the maximum for carriages; that they are very rapid when 15°, which is the maximum for loaded beasts of burden; that an inclination of 35° is so great, that we cannot ascend it without cutting steps in the rock; and that, even with the aid of steps, an inclination of more than 44° is very difficult of ascent.

The Summit.—This is usually the smallest part of a mountain, and its inclination is generally less considerable than that of the acclivity. There occur, however, exceptions to this: thus there are summits that rise more rapidly than the acclivity; and these are usually very high, almost of equal length with the acclivity, and completely naked. Such lofty and precipitous summits are, in Switzerland, denominated *Peaks*. The summit varies considerably in its shape: it is tabular, or round-backed, or obtuse, or acute, or short conical. Generally the shape of the mountain is characteristic of the rock of which it is composed. Thus gneiss and transition rocks form flat or round-backed summits; clay-slate, conical summits; and basalt and some other rocks, short and obtuse conical summits: granite and limestone often present extremely sharp pointed summits or peaks.

The summits of mountains are sometimes divided by means of ravines, and these are to be considered as the smallest kind of valley. They form one extremity of the series of which the principal valleys in mountain groups form the other. The inequalities formed on the summits of mountains by these ravines or very small valleys, are denominated *Caps*. A mountain may have many caps, and the highest of these will be the *top* of the mountain.

17. Mountain groups may be considered under five different points of view, namely, according to their *length*, *height*, *breadth*, *shape of the mountains*, and *their connection*.

18. Mountain groups, in regard to their length, may be divided into *principal*, *middle*, and *small*.

A principal mountain group or Alpine country must be at least 130 miles long. They occur but seldom. The Alps of Switzerland, the Pyrenees, and the Carpathians, afford examples of this kind.

A middle-sized mountain group is from 40 to 130 miles in length. The greater number of European mountain groups belong to this class; as examples, we may mention the Grampians, Hartz, the Reisen or Giant Mount ins, &c.

A small mountain group is from 10 to 40 miles in length, as examples of it, we may mention the Forest of Turingia, and the Bohemian Mittelgebirge.

19. Mountain groups, in regard to their height, are by [illegible]graphers divided into *high*, *of a middle height*, and *low*

A high mountain group is above 1000 toises or fathoms in height. In Europe, almost the only examples of this class are, the Alps of Switzerland, Savoy, the Tyrol, and the Pyrenees. In the Alps of Switzerland, the highest point is Mont Blanc, which is about 15,646 feet above the level of the sea. The Jungfrau-horn is 13,730 feet above the level of the sea. In the Tyrolean Alps, the Gross Glockner reaches the height of 12,780 above the sea; and the Ortler 15,430. In the Pyrenees, the highest point is Mont Perdu, which is 11,283 feet above the sea.

The elevations in South America are much more considerable. Thus Antisana is 19,150; Tonguragua 16,579; Cotopaxi, according to Condamine, 18,890. Chimborazo, the most elevated summit in the new world, is 21,440 feet above the level of the sea.

The Himalya mountain in Asia is still higher, having, in some instances, an elevation of 27,000 feet.

In Asia, Africa, and America, there appear to be many mountain groups that belong to this division.

20. Mountain groups of a *middle* height are from 500 to 1000 toises high. These are not uncommon. In Germany, the Erzgebirge, Fichtelgebirge, Riesengebirge, and Hartz, are of this magnitude. The highest point of the Fichtelgebirge is 3600 feet; of the Hartz nearly the same. The Schneekoppe in the Riesengebirge is 4949 feet above the sea.

21. *Low* mountain groups are from 600 to 3000 feet high. These are the most numerous. The Schwarz-Wald or Black Forest, the mountains between Moravia and Bohemia, the Thuringer-Wald, &c. belong to this class.

22. Mountain groups, in regard to the breadth of their base, are divided into *massive* and *longish* groups.

In *massive* mountain groups, the length and breadth of the base are nearly alike. The Swiss and Tyrolian Alps, and the Hartz, are of this kind.

In the *longish* mountain group, the length of the base is very considerable in comparison of the breadth. Of this kind are the Riesengebirge, Erzgebirge, &c. The greater number of groups have this shape.

23. Mountain groups, in regard to the form of the mountains of which they are composed, are divided into *common*, *conical* and *alpine* groups.

In the *common* mountain group, the individual mountains of which the chains are composed are singly aggregated, and are joined nearly to their summits.

In the *conical* mountain group, the individual mountains of which the chains are composed, are also singly aggregated, but not joined together higher up than the declivity; so that they appear conical.

In the *alpine* mountain group, the mountain chains are composed, not of single mountains joined together, but of groups of pyramidal-shaped mountains, in which groups a large pyramidal mountain has arranged around it a number of smaller mountains of the same figure.

24. Mountain groups, in regard to their connection, are either *isolated*, or several are joined together, forming a *chain* of mountain groups. A chain of mountain groups extends from the Alps of Switzerland to Servia and Bulgaria: a similar range is formed by the Fichtelgebirge, which is connected with the Carpathians by the Alpine land or mountain groups of the Erzgebirge, Riesenbirge, Silesian and Moravian groups.

25 *Plains*, as we have already mentioned, form the principal constituent part of *low land*; yet there frequently occurs in it flat hilly land, more rarely low and isolated groups; and the hills are often isolated, and at a considerable distance from each other.

The plains of the low land are characterized by particular hollows or concavities, which are denominated *river valleys*, or *river courses*. In these there are to be distinguished the *bed of the river*, and the *holm* or *haugh* land: Further, there are to be observed the *high* and *low bank* of the river, and the ravines or small valleys that traverse the high bank, and terminate in the low bank.

There is still another kind of hollow to be observed in *low* land; it is that formed by shallow and wide-extended lakes. Numerous instances of this are to be observed in the great European low land. The Marc Brandenburg affords many instances of these latter. We further observe, that the plains of the low land are not perfectly level, but are frequently marked with rising grounds, which can scarcely be entitled to the name of hills. They often extend for many miles. They are denominated by German geognosts *Landhöhen*, when they are nearly of equal length and breadth; and *Landrücken*, when they have a lengthened form.

Humboldt, in his valuable book of travels, gives an interesting account of the great plains of South America, which we shall here lay before our readers.

In the Mesa de Paja, in the 9th degree of South latitude, says Humboldt, we entered the basin of the Llanos. The sun was almost at the zenith; the earth, wherever it appeared, sterile and destitute of vegetation, was at the temperature of 48° or 50° centigrade. Not a breath of air was felt at the height we were on the mules; yet, in the midst of this apparent calm, whirls of dust incessantly arose, driven on by the small currents of air that glide only over the surface of the ground, and are occasioned by the difference of temperature, which the naked sand and the spots covered with herbs acquire. These *sand winds* augment the suffocating heat of the air. Every grain of quartz, hotter than the surrounding air, radiates heat in every direction; and it is difficult to observe the temperature of the atmosphere, without these particles of sand striking against the bulb of the thermometer. All around us, the plains seemed to ascend towards the sky, and that vast and profound solitude appeared to our eyes like an ocean covered with sea weeds. According to the unequal mass of vapours diffused through the atmosphere, and the variable decrement in the temperature of the different strata of the atmosphere, the horizon in some parts was clear and distinct; in other parts it appeared undulating, sinuous, and as if striped. The earth was there confounded with the sky. Through the dry fog and strata of vapour, the trunks of palm-trees were seen from afar. Stripped of their foliage, and their verdant summits, these trunks appeared like masts of a ship discovered at the horizon.

There is something awful, but sad and gloomy, in the uniform aspect of these steppes. Every thing seems motionless; scarcely does a small cloud, as it passes across the zenith, and announces the approach of the rainy season, sometimes cast its shadow on the savannah. I know not whether the first aspect of the llanos excite less astonishment than that of the chain of the Andes. Mountainous countries, whatever may be the highest elevation of the highest summits, have an analogous physiognomy; but we accustom ourselves with difficulty to the view of the llanos of Venezuela and Casanary, to that of the *Pampas* of Buenos-Ayres and of Chaco, which recal to the mind incessantly, and during journeys of twenty or thirty days, the smooth surface of the ocean. I had seen the plains or llanos of La Mancha in Spain, and the heath-lands that extend from the extremity of Jutland, through Luneburg and Westphalia, to Belgium. These last are real steppes, of which man, during several ages, has been able to subject only small portions to cultivation; but the plains of the west and north of Europe present a feeble image of the immense llanos of South America. It is in the south-east of our Continent, in Hungary, between the Danube and the Theiss; in Russia, between the Borysthenes, and the Don, and the Wolga, that we find those vast pastures, which seem to have been levelled by a long abode of the waters, and terminate the horizon on every side. The plains of Hungary, when I traversed them, on the frontiers of Germany, between Presburg and Oldinburg, strike the imagination of the traveller by the constant display of the *miràge*, or extraordinary refractions; but their greatest extent is more to the east, between Czegled, Debreczen, and Tittel, which has only two outlets, one near Grau and Waitzen; the other between Belgrade and Widdin.

The different parts of the world have been supposed to be characterized by saying, that Europe has it *heath lands*, Asia its *steppes*, Africa its *deserts*, and America its *savannahs;* but by this distinction contrasts are established, that are not founded either in the nature of things, or the genius of languages. The existence of a heath always supposes an association of plants of the family of *ericæ;* the steppes of Asia are not every where covered with saline plants; the savannahs of Venezuela furnish not only the gramina, but with these small herbaceous mimosas, leguinina, and other dicotyledonous plants. The plains of Songaria, those which extend between the Don and the Wolga, and the *Puszta* of Hungary, are real savannahs, pasturages abounding in grasses; while the savannahs to the east and west of the Stony mountains, and of New Mexico, produce chenopodiums, containing muriate and carbonate of soda. Asia has its real deserts, destitute of vegetation, in Arabia, in Gobi, and in Persia. Since we have become better acquainted with the deserts in the interior of Africa, so long and so vaguely confounded together under the name of Desert of Sahara (Zahra,) it has been observed, that in this continent, toward the east, savannahs and pastures are found, as in Arabia, set in the midst of naked and barren tracts. It is these last, these deserts covered with gravel, and destitute of plants, that are almost entirely awanting in the New World. I saw them only in the low part of Peru, between Amotape and Coguimbo, on the borders of the South Sea. These are called by the Spaniards, not Llanos, but the *Desiertos* of Sechura and Atacamez. This solitary tract is not broad, but 440 leagues long. The rock pierces every where through the quicksands. No drop of rain ever falls on it; and, like the desert of Sahara, to the north of Tombuctoo, the Peruvian desert affords, near Huara, a rich mine of rock-salt. Every where else, in the New World, there are plains, desert because not inhabited, but no real deserts.

The same phenomena are repeated in the most distant regions; and, instead of designating those vast plains, destitute of trees, by the nature of the plants they produce, it seems natural to distinguish them into *deserts*, and *steppes* or *savannahs;* into bare lands without any appearance of vegetation, and lands covered with gramina, or small plants of the dicotyledonous tribe. The savannahs of America, especially those of the temperate regions, have, in many works, been designated by the name *prairies;* but this term appears to me little applicable to pastures that are often very dry, though covered with grass of four or five feet in height. The *llanos* and the *Pampas* of South America are real steppes. They display a beautiful verdure in the rainy season, but in the time of great drought assume the aspect of a desert. The grass is then reduced to powder; the earth cracks; the alligator and the great serpents remain buried in the dried mud till awakened from their long lethargy by the first showers of spring. These phenomena are observed in barren tracts of fifty or sixty leagues in length, wherever the savannahs are not traversed by rivers; for on the borders of rivulets, and around little pools of stagnant water, the traveller finds, at certain distances, even during the period of the great droughts, thickets of mauritia, a palm, the leaves of which, spread out like a fan, preserve a brilliant verdure.

The steppes of Asia are all beyond the tropics, and form very elevated table-lands. America, also, displays savannahs of considerable extent on the backs of the mountains of Mexico, Peru, and Quito; but its most extensive steppes, the Llanos of Cumana, Caraccas and Meta, are little raised above the level of the ocean, and all belong to the equinoctial zone. These circumstances give them a peculiar character. They have not, like the steppes of southern Asia, and the deserts of Persia, those lakes without issue, those small systems of rivers, that lose themselves either in the sands, or by subterraneous filtrations. The Llanos of America are inclined towards the east and south, and their running waters are branches of the Oroonoko.

The course of these rivers had once led me to believe that the plains formed table-lands, raised at least from one hundred to one hundred and fifty toises above the level of the ocean. I supposed that the deserts of interior Africa were also at a considerable height; and that they rose one above another, like stages, from the coast to the interior of the continent. No barometer has yet been carried into the Sahara. With respect to the llanos of America, I found by barometric heights, observed at Calabozo, at the Villa del Pao, and at the mouth of the Meta, that their height is only 40 or 50 toises above the level of the sea. The fall of the river is extremely gentle, often nearly imperceptible; and, therefore, the least wind, or the swelling of the Oroonoko, causes a reflux in those rivers that flow into it. The Indians believe they descend during a whole day in navigating from their mouths towards their sources. The waters that descend are separated from those that flow back by a great body of stagnant water, in which the equilibrium being disturbed, whirlpools are formed that are dangerous for boats.

The chief characteristic of the savannahs, or steppes of South America, is the absolute want of hills and inequalities, the perfect level of every part of the soil. Often in a space of thirty leagues there is not an eminence of a foot high. This resemblance to the surface of the ocean strikes the imagination most powerfully, where the plains are altogether destitute of palm-trees; and where the mountains of the shore, and of the Oronooko are so far distant, that they cannot be seen, as in the *Mesa de Pavones*. The equality of surface is still more perfect in the meridian of Calabozo than towards the east, between the Cari, La Villa del Pao, and Nueva Barcelona; but it reigns without interruption from the mouths of the Oronooko to Lavella de Araure and Ospinos, under a parallel of an hundred and eighty leagues in length; and from San Carlos to the savannahs of Caqueta, on a meridian of two hundred leagues. It particularly characterises the new continent, as it does the low steppes of Asia, between the Borysthenes and the Wolga, between the Irtisch and the Obi. The deserts of central Africa, of Arabia, Syria, and Persia, Cobi, and Casna, present, on the contrary, many inequalities, ranges of hills, ravines without water, and rocks that pierce the sands.

The llanos, however, notwithstanding the apparent uniformity of their surface, furnish two kinds of inequalities, that do not escape the observation of an attentive observer. The first is known by the name *Bancos;* they are real shoals in the basin of the steppes, fractured strata of sand-stone, or compact lime-stone standing four or five feet higher than the rest of the plain. These *banks* are sometimes three or four leagues in length; they are entirely smooth, with a horizontal surface; their existence is only perceived by examining their borders. The second species of inequality can be recognised only by geodesical or barometric levellings, or by the course of rivers. It is called *Mesa*, and is composed of small flats, or rather convex eminences, that rise insensibly to the height of a few toises.

The uniform landscape of the llanos; the extreme rarity of inhabitants; the fatigue of travelling beneath a burning sky, and an atmosphere darkened by dust; the view of that horizon, which seems for ever to fly from before us; those lonely trunks of palm-trees, which have all the same aspect, and which we despair of reaching, because they are confounded with other trunks that rise by degrees in the visual horizon; all these causes combined, make the steppes appear far greater than they are in reality. The planters who inhabit the southern declivity of the chain of the coast, see the steppes extend toward the south, as far as the eye can reach, like an ocean of verdure. They know that from the Delta of the Oronooko to the province of Varinas, and thence, by traversing the banks of the Mela and the Guaviare, and the Caguan, they can advance three hundred and eighty leagues in the plains, first from east to west, and then from north-east to south-west, beyond the equator, to the foot of the Andes of Pasto. They know, by the accounts of travellers, the Pampas of Buenos Ayres, which are also llanos covered with fine grass, destitute of trees, and filled with oxen and horses become wild.

26. In mountainous and hilly country, funnel-shaped hollows of different sizes are sometimes to be observed. The smallest kind have been formed by the sinking of rocks, and are peculiar to certain formations. The others are circular valleys: a stream or river usually traverses them, and disappears by a subterranean canal. Hence it happens that these hollows are sometimes filled with water, and at other times dry. The Lake of Cirknitz is an example of this kind of valley.

27. We obtain a very distinct conception of the surface of the earth, by comparing together the different inequalities that have been described, and we are much assisted in forming this conception, by attending to the course of the water over the earth's surface. We can, by means of the course of rivers, distinguish great portions of the surface of the earth, which are termed *river districts* by geographers. These districts are generally very wide and flat troughs or concavities, in which the main river occupies the lower, and its exit from the concavity the lowest point of the district. In good maps we can trace out these districts, by drawing lines along the points where the small rivers and rivulets of

the district took their rise; and thus we obtain the boundary of the river district.

In the *high land*, river districts form peculiar basins or concavities; and these sometimes form connected series. They are often contained in the mountain group, but more frequently without them; but still in the high land. Thus the Vallais, which is a concavity of this kind, lies between the Alps of Switzerland and Savoy; and the vicinity of Geneva affords another similar example. The river district of the Rhine forms many basins of this kind, in its course towards the ocean. As long as it continues in the Alps, these basins are inconsiderable; but they increase in magnitude as soon as it leaves those elevated regions. The basin in which the Lake of Constance is situated, may serve as an example. A second basin of the Rhine occurs in Baden, where it is increased by many lateral streams. It extends from Upper Alsace to Hundsruck, and the vicinity of Mayence; where the Rhine forces its way through a narrow rocky passage. The river district of the Danube forms a basin in Swabia, several in Bavaria, and one in Lower Austria, but is nearly shut up at Presburg, which forms the entrance into the great valley of Hungary. At the lower extremity of Hungary, the river is again forced to seek its way through a narrow rocky channel at Orosova, which is the only opening from Hungary into Wallachia. It now continues its course through Wallachia, and at length falls into the Black Sea. We have a continuation of these valleys or basins, although still filled with water, in the Black Sea, Sea of Marmora, and Mediterranean. This latter fact is particularly interesting, as it leads to interesting considerations in regard to the former state of such basins or valleys. Bohemia affords another example of this kind. That extensive country is a great circular valley, whose bottom inclines towards the only opening of the valley, above Konigstein, through which the river Elbe issues, carrying with it nearly all the water that falls on Bohemia. Immediately below this narrow rocky outlet, there is another small circular valley, which extends from Konigstein to Pirna. At Pirna it is nearly closed up, the river forcing its way through a narrow rocky opening, and at length it enters a very beautiful valley, in which the city of Dresden is situated. This valley, as we approach Meissen, which is further down the Elbe, becomes narrow, and the river again flows through a rocky channel, until it escapes into the low country, through which it winds and traverses the flats of Lower Saxony, and is at length poured into the North Sea at Cuxhaven. The river Don, in Aberdeenshire, also passes through several circular or inclosed valleys, in its course to the ocean. At its estuary, the rocks confine it to a narrow channel; but on ascending on it for about a mile, the hills recede from it, so as to form a considerable extent of country on each side. About Inverury it again appears to flow through a channel; and still farther up it flows through another spacious valley. This valley continues for a considerable extent; it at length contracts, and the river flows through another rocky channel. It continues in this channel for a considerable distance, until it again flows through another wide valley.

In the county of Dumfries there are appearances of the same kind, as in the course of the Nith, in which we have the valleys of Sanquhar, Closeburn, and Dumfries; also in other parts of Scotland.

Similar appearances are to be observed in almost every quarter of the globe; and many of the lakes we see so abundantly distributed over the surface of the globe are to be considered as similar basins, but filled with water.

28. Having in the preceding sections described the various inequalities observable on that portion of the surface of the globe which is elevated above the level of the sea, we may now give a short description of the inequalities discoverable on the *bottom of the sea*, or that part of the globe which is still covered with water.

From the observations of mariners, we learn that the bottom of the sea has very considerable inequalities, and that these correspond, in many respects, to those observed on the surface of the land. Indeed this must be the case, when we consider that the present dry land was formerly the bottom of the sea. In paragraph 6. we mentioned, that it does not present so great a variety, or so beautiful a system of elevations and depressions, as the dry land; and this difference is also easily explained. The submarine land must be exposed, for many ages, to the action of the waves of the ocean, and of rain, rivers, and lakes, before its surface can agree, in all its features, with that of the dry land.

When the ground at the bottom of the sea approaches near to the surface of the water, and is pretty level, it is denominated a *shoal*. The Dogger Bank, in the North Sea, is an example of the shoal surface. It resembles the plains on the dry land; it makes the transition from the dry land to the submarine, and will no doubt one day be changed into a plain. *Deep submarine plains* also often occur. Sometimes the bottom of the sea has a very uneven surface, and is composed of *hills*, either of sand and gravel, particularly near the coast, (as is the case on the coast of Holland), or of rocky hills, or of cliffs and other irregularities. The summits of these submarine hills form islands, and these sometimes appear as continuations of the high country on the dry land. We sometimes also meet with great hollows, which are unfathomable.

The coral reefs that surround the islands in the South Sea and Indian Ocean are to be viewed as a variety of the shoal surface already mentioned. These are the work of very minute animals. They occur in vast abundance along the east coast of New Holland, and in the South Sea, particularly to the eastward of the Friendly Islands, from the 10° to 15° South Latitude. A reef of this kind surrounds the island of Otaheite, and rises like a wall from unfathomable depths. Many of the other islands are encompassed with similar reefs, in particular New Holland, New Caledonia, &c. Captain Flinders says, the quantity of coral reefs between New Holland and New Caledonia and New Guinea is such, that this might be called the coral sea. Thus for 350 miles, in a straight line from south-east to north-west, in the east coast of New Holland, is a coral reef uninterrupted by any large opening into the sea, and this reef is probably connected with others, so as altogether to form an extent of upwards of 1000 miles, and having a mean breadth of from 20 to 50 miles. These reefs sometimes give rise to islands. The coral rises above the surface of the water, disintegrates, becomes mixed with seeds of different kinds, carried by birds, floated by the waves, or wafted by the winds. These grow and decay, and thus afford a more or less deep covering of soil, on which the cocoa nut and other large trees take root and grow. Palmerston island, the island of Tanea, the island of Middleburg, the island of Tongataboo, the island of Mangea, and others in the South Sea, have a base of coral.

The following details in regard to the formation of coral reefs and islands, as given by Dr. Forster and Captain Flinders, will increase the interest of the preceding account. Dr. Forster remarks, "All the low isles seem to me to be a production of the sea, or rather its inhabitants, the polype-like animals forming the lithophytes. These animalcules raise their habitation gradually from a small base, always spreading more and more, in proportion as the structure grows higher. The materials are a kind of lime mixed with some animal substance. I have seen these large structures in all stages, and of various extent. Near Turtle Island, we found, at a few miles distance, and to leeward of it, a considerable large circular reef, over which the sea broke every where, and no part of it was above water; it included a large deep lagoon. To the east and north-east of the Society Isles, are a great many isles, which, in some parts, are above water; in others, the elevated parts are connected by reefs, some of which are dry at low water, and others are constantly under water. The elevated parts consist of a soil formed by a sand of shells and coral rocks, mixed with a light black mould, produced from putrified vegetables, and the dung of sea-fowls; and are commonly covered by cocoa-nut trees and other shrubs, and a few anti-scorbutic plants. The lower parts have only a few shrubs, and the above plants; others, still lower, are washed by the sea at high water. All these isles are connected, and include a lagoon in the middle, which is full of the finest fish; and sometimes there is an opening, admitting a boat or canoe in the reef, but I never saw or heard of an opening that would admit a ship.

"The reef, or the first origin of these isles, is formed by the animalcules inhabiting the lithophytes. They raise their habitation within a little of the surface of the sea, which gradually throws shells, weeds, sand, small bits of corals, and other things, on the tops of these coral rocks, and at last fairly raises them above water; where the above things continue to be accumulated by the sea, till by a bird, or by the sea, a few seeds of plânts, that commonly grow on the sea shore, are thrown up and begin to vegetate; and by their annual decay and reproduction from seeds, create a little mould, yearly accumulated by the mixture with sand, increasing the dry spot on every side; till another sea happens to carry a cocoa-nut hither, which preserves its vegetative power a long time in the sea, and therefore will soon begin to grow on this soil, especially as it thrives equally in all kinds of soil; and thus may all these low isles have become covered with the finest cocoa-nut trees.

"The animalcules forming these reefs, want to shelter their habitation from the impetuosity of the winds, and the power and rage of the ocean; but as, within the tropics, the winds blow commonly from one quarter, they, by instinct, endeavour to stretch only a ledge, within which is a lagoon, which is certainly entirely screened against the power of both; this therefore might account for the method employed by the animalcules in building only narrow ledges of coral rocks, to secure in their middle a calm and sheltered place; and this seems to me to be the most probable cause of THE ORIGIN of all THE TROPICAL LOW ISLES, over the whole South Sea."

Captain Flinders, gives the following interesting account of the formation of Coral Islands, particularly of Half-way Island on the north coast of Terra Australis. Vol. ii. p. 114, 115, 116.

"This little island, or rather the surrounding reef, which is three or four miles long, affords shelter from the south-east winds; and being at a moderate day's run from Murray's Isles, it forms a convenient anchorage for the night to a ship passing through Torres' Strait; I named it *Half-way Island*. It is scarcely more than a mile in circumference, but appears to be increasing both in elevation and extent. At no very distant period of time, it was one of those banks produced by the washing up of sand and broken coral, of which most reefs afford instances, and those of Torres' Strait, a great many. These banks are in different stages of progress; some, like this, are become islands, but not yet habitable; some are above high-water mark, but destitute of vegetation; whilst others are overflowed with every returning tide.

"It seems to me, that when the animalcules which form the corals at the bottom of the ocean, cease to live, their structures adhere to each other, by virtue either of the glutinous remains within, or of some property in salt water; and the interstices being gradually filled up with sand and broken pieces of coral washed by the sea, which also adhere, a mass of rock is at length formed. Future races of these animalcules erect their habitations upon the rising bank, and die in their turn, to increase, but principally to elevate, this monument of their wonderful labours. The care taken to work perpendicularly in the early stages, would mark a surprising instinct in these diminutive creatures. Their wall of coral for the most part, in situations where the winds are constant, being arrived at the surface, affords a shelter, to leeward of which their infant colonies may be safely sent forth; and to this their instinctive foresight it seems to be owing, that the windward side of a reef exposed to the open sea, is generally, if not always, the highest part, and rises almost perpendicular, sometimes from the depth of 200, and perhaps many more fathoms. To be constantly covered with water, seems necessary to the existence of the animalcules, for they do not work, except in holes upon the reef, beyond low-water mark; but the coral sand and other broken remnants thrown up by the sea, adhere to the rock, and form a solid mass with it, as high as the common tides reach. That elevation surpassed, the future remnants, being rarely covered, lose their cohesive property; and remaining in a loose state, form what is usually called a *key*, upon the top of the reef. The new bank is not long in being visited by sea birds; salt plants take root upon it, and a soil begins to be formed; a cocoa-nut, or the drupe of a pandanus, is thrown on shore; land birds visit it, and deposit the seeds of shrubs and trees; every high tide, and still more every gale, adds something to the bank; the form of an island is gradually assumed, and last of all comes man to take possession.

"Half-way Island is well advanced in the above progressive state; having been many years, probably some ages, above the reach of the highest spring tides, or the wash of the surf in the heaviest gales. I distinguished, however, in the rock which forms its basis, the sand, coral, and shells, formerly thrown up, in a more or less perfect state of cohesion. Small pieces of wood, pumice stone, and other extraneous bodies, which chance had mixed with the calcareous substances when the cohesion began, were inclosed in the rock; and in some cases were still separable from it without much force. The upper part of the island is a mixture of the same substances in a loose state, with a little vegetable soil; and is covered with the *casuarina* and a variety of other trees and shrubs, which give food to parroquets, pigeons, and some other birds; to whose ancestors, it is probable, the island was originally indebted for this vegetation.

CHAP. II.

EFFECTS OF WATER AND VOLCANOES ON THE SURFACE OF THE EARTH.

29. Having now described all the varieties of inequality observed on the surface of the dry land, it will be interesting to endeavour to discover how these have been formed.

Many of the elevations and hollows appear to be original formations, while others seem to be more particularly the effects of water and of volcanic fire. We shall consider each of these in particular.

30. Water acts either *chemically* or *mechanically* on the surface of the earth: and it may further be considered, according to its destroying and forming effects.

Destroying Effects of Water.

We shall first consider the *mechanical destroying effects of water.*

Every long continued rain convinces us of the powerful mechanical effects of water on the surface of the earth. The precipitated water penetrates the surface, then flows along mixed with the matter of the soil, and in its course forms small water-courses, and occasions considerable changes in the flat country and the declivities of mountains. As it rains a very considerable portion of the year, and as every rain carries along with it a quantity of the soil, very obvious changes must in this manner be induced on the surface of the globe. Thunder storms and water-spouts, although more uncommon phenomena, produce more considerable changes, and this either alone, or when their waters join or flow into rivers. These deprive whole districts of their soil to the bare rock; they sometimes even form small ravines, and break down and carry away great masses of rock, that were either formerly much rent, or of such a form as to be easily overpowered by water. If such changes take place in the low land, they must be vastly more considerable in the high land.

The thaw-floods that take place in low countries towards the end of winter and beginning of spring, and in mountainous districts during summer, occasion still greater changes on the surface of the earth. Their effects are truly frightful, particularly when accompanied with rain. The declivities in low countries, over which water flows, are less considerable than in high countries; and besides, the water can extend itself farther in low and flat countries; hence its destroying effects are diminished in intensity. In mountainous countries, on the contrary, the fall is much greater than in flat countries, and the water is compressed into narrow rocky valleys; hence it follows, that rain-floods must be more destructive, the more considerable the quantity of water, and the more mountainous the country. These floods are still more destructive, when the mountain rocks are of such a nature, as to afford little resistance to the impetuosity of the water; that is, when they are decomposed, loose in their texture, or have such a shape as to allow the water to act more easily on them. If we compare together all these circumstances, we shall find that mountainous countries are more liable to suffer from the effects of floods, than low and flat countries. To this, indeed, there are exceptions, as in the case in some granites, and other rocks that long resist the effects of the most powerful and violent floods.

The water of these floods, in its progress towards the lower parts of the earth, flows either into ravines, and from these into valleys and beds of rivers; or when it meets with no ravine, scoops out a bed for itself, wherever it meets with a soft yielding rock or a slight hollow. The junction of these mountain streams with the river of the district, not only increases its power by the addition of a considerable quantity of water, but also causes it to overflow its banks, and deluge the neighbouring country, and thus to occasion great changes on its surface. The different loose materials are carried towards the sea, and are deposited at different distances from the mouth of the river; and these are proportioned to the magnitude of the masses. The finest or loamy parts reach the sea; the sand, gravel, and larger rolled masses being left on the surface at greater or less distance from the sea, according to the relative magnitude of their parts.

This mechanical action of water appears in many cases to have contributed in an eminent degree to the hollowing out of valleys; but all valleys have not been formed in this manner; for many and very extensive valleys are formed by mountain groups disposed in a circular form, as is the case in Bohemia, Hungary, Transylvania, &c.; others by the original inequalities of the crust of the earth; some by the unequal deposition of formations, and others by the widening of great rents.

It is also observed, that numerous rents and fissures, and the fall of great masses of mountains, take place during floods or wet seasons. These falls are occasioned either by the weight of the masses being increased by the great quantity of absorbed water, or by the diminished cohesion of the parts of the rock effected by the same cause, or by the splitting of great masses by freezing of water, or any other power that interrupts the continuity of the rock, and favours its separation into different masses. The fall of rocks is also occasioned by the softening and removal of subjacent strata or beds by means of water.

These masses sometimes interrupt the course of rivers, and thus form lakes. These lakes in their turn again force a passage through this inclosing barrier, and sometimes so suddenly as to deluge and desolate the lower country.

In the year 1618, the once considerable town of Plurs, in Graubunden, with the neighbouring village of Schilano, were overwhelmed by an immense mountain mass, which separated with a frightful noise from the south side of the mountain of Corto. In 1678, the sinking of several great masses of rocks in the Pyrenees caused very violent overflowings in Gascony. In 1714, the west side of the Diableret, in the Vallais, fell down, and covered the neighbouring country with its ruins for two miles in length and breadth, and the immense blocks of stone interrupted the course of the rivers; and lakes were thus formed. Many similar instances are on record in France, Italy, England, Scotland, &c. When the barriers of lakes, in high and mountainous countries, burst during great thaws or uncommon floods of rain, tremendous overflowings of the lower country that almost exceed conception are the consequence. Immense masses of rock are torn away and carried to an inconceivable distance, and whole countries are desolated. Many of the deluges mentioned by ancient writers appear to have been caused by the bursting of lakes.

The Waller Lake, in the Tyrol, rose so much, owing to the melting of the ice of the neighbouring glaciers, that it broke through its natural barrier; and its water was precipitated with so much velocity and violence into the lower country, that whole valleys and plains were desolated. The bursting of a lake in the valley of Bagne occasioned great devastation. There are many other instances of lakes having emptied themselves in other parts of Switzerland, as also in the Fichtelgebirge, &c.

The waters of the ocean also act very powerfully in breaking down the land. Its waves and currents are particularly active in these destroying operations. They either hollow out the rocks on the coast into caves of greater or less magnitude, or, by washing away softer subjacent strata, cause sinkings and fallings of great masses of rock. The caves in the islands of Arran and Jura have been partly formed in this manner.

If many streams act in different directions on the same coast, or in conjunction with land-floods, as is often the case, the destroying effect is very great. Frequently also the power of the flood is increased by ebb and flood tide. In this manner many maritime countries have been overwhelmed by the sea.

The Baltic Sea affords examples of these destroying effects; thus the island of Rugen was formerly joined to the Continent, but, by the violent action of the sea, has been much diminished in magnitude, and separated from it. The effects it has produced on the coasts of Carniola, Dalmatia and Egypt, are well known. The Zuyder-zee, which is contained between the provinces of Holland, Utrecht, Gelders, Overyssel, and Friesland, was formerly a lake, through which an arm of the Rhine, named the Flevo, flowed towards the ocean. In the 13th century the sea broke in, covered the whole country, and left only detached portions of the land, which now form the islands denominated Texel, Vlieland, Schelling, Newland, and others, that now serve to defend this sea from the power of the waves of the ocean. This remarkable change is supposed to have been occasioned by a violent land-flood, in conjunction with high tides, and a high wind blowing in an opposite direction to the course of the river.

In the year 1164, a violent storm of wind caused a deluge in Friesland, which occasioned the death of many thousand persons. In 1218, another inundation in Friesland occurred, by which 100,000 persons were drowned; and another equally destructive took place in 1530. Florus speaks of a rising of the water in the year of Rome 644, which forced the Teutonians, Cimbrians, and Tigurians, back from the countries they inhabited. This was occasioned by a violent north wind, which raised the ocean along the coast of the countries they inhabited.

Water in the state of ice, also produces considerable changes on the surface of the earth. Thus we often observe masses from a hundred weight to many tons floated by rivers during thaw-floods, and these frequently break up the banks of the rivers, and even tear away immense masses of solid rock. Sea-ice also produces similar effects on coasts, but on a greater scale.

It sometimes happens, that great fields of ice rise from the bottom, and bring with them masses of rock several hundred tons weight. These masses of stone are embedded in the ice. They are carried along with the ice, and deposited on shores at a great distance from their original situation. This fact will serve to explain the appearance of loose blocks of particular kinds, in situations far removed from their original repository.

Similar changes are occasioned by the fall of ice from the heights of mountains. When the glacier, or mountain ice, rests on inclined planes, dreadful devastation is caused by it, during the time of floods, as it then splits, and is hurled down to the lower country with irresistible impetuosity. The inhabitants of the Alps of Switzerland and Savoy, of Iceland and Greenland, often experience the terrible effects of the fall of these tremendous masses.

In like manner, the fall of snow produces striking effects. The consolidated snow is often precipitated with great velocity, accompanied with terrible noises, carrying along with it rocks of vast size, and often burying villages under it.

The freezing of water contained in the fissures of rocks also occasions considerable alterations on the surface of the earth. This is observed most particularly in those rocks that have perpendicular fissures, because these allow the water to enter more easily, and favour the separation of the masses when the water expands during the process of freezing. Hence we find no species of rock more changed by the effects of frost than basalt and porphyry-slate.

The *Chemical effects* of water, particularly the destroying effects, depend on the kind of rock over which it flows; for some allow water to act on them chemically, others do not. Limestone, gypsum, and rock-salt, are more particularly acted on by water than most other rocks.

By this agency of water, the height of limestone and gypsum mountains is gradually diminished, caves are excavated in them, and the water of such countries is much impregnated with gypseous and calcareous matters. The rock-salt which occurs in hills of gypsum is often dissolved by the water, and thus cavities of considerable magnitude are formed; and by the continued action of the water on the gypsum, the cavities increase in size, until the superincumbent pressure becomes too great, and then the roof falls in and forms those remarkable funnel-shaped hollows so often observed in gypsum countries.

Sometimes, as in felspar rocks, the percolating water washes away the alkaline ingredient; in other cases, the moisture combines with iron, and forms hydrate, or by its decomposition oxidates the metallic substances in a greater or less degree. By its action on sulphurous compounds, as on pyrites, it gives rise to sulphates or vitriols. As iron is the most general and abundant metal in the mineral kingdom, and is easily acted on by air and moisture, it follows that it must be one of the most active agents in the disintegration of mineral substances.

Forming Effects of Water.

We shall next consider the *forming* effects of water, which are, as already mentioned, either *mechanical* or *chemical.*

It is evident, that every mechanical destruction will be followed by a mechanical formation; for the masses which are separated by the water will be again deposited on the surface of the land, in lakes, rivers, on coasts, or on the bottom of the sea. During land floods, the water does not always convey its mechanically mixed parts to rivers; on the contrary, it often deposites them in hollow places. Those particles that reach rivers form sand-banks, particularly in slow-flowing rivers. Very extensive mechanical formations are daily taking place on the coasts, and even in some places at a considerable distance from them, by the waters of the ocean. In the Baltic or East Sea, many appearances of this kind are to be observed. Thus the Bay of Fulbaka, which was navigated with boats within the memory of man, is now filled up, and covered with grass. Several harbours in Lapland that formerly admitted vessels, are now three or four thousand paces from the sea; and at Helsingor there are iron-works in places which were covered by the sea about eighty years ago. The whole of the ancient kingdom of Prussia appears to have been formed in this manner; it is said that the sea reached as far as Culm within the period of human history. The city of Dantzic, several hundred years ago, was close on the sea-shore.

Similar appearances occur on other coasts. Between the coasts of Norfolk and Zealand in Holland, there is a great sand-bank, where opposite currents meet, and it is probable that this bank will in time form an island, and probably even an isthmus. Much of the country of the United Provinces has been produced by the forming action of the sea.

A great portion of the flat country from the mouth of the Rhone to the Pyrenees is said to be the work of the ocean; and the whole tract of country from Pisa to Leghorn is a formation of the same nature.

In those parts of the sea where its waters are but little agitated, similar forming effects are to be observed.

Where marine currents flow rapidly, and near the coast, they exert a destroying power, but when they act at a distance, a forming power.

The effects produced by the sea alone, without the aid of rivers, are far less beneficial. When the sea-coast is low, and the bottom consists of sand, the waves push this sand towards the shore, where, at every reflux of the tide, it becomes partially dried; and the winds, which almost always blow from the sea, drift up some portion of it upon the beach. By this means *downs*, or ranges of low sand hills, are formed along the coast. These, if not fixed by the growth of suitable plants, either denominated by nature, or propagated by human industry, would be gradually, but certainly, carried towards the interior, covering up the fertile plains with their sterile particles, and rendering them unfit for the habitation of mankind, because the same winds which carried the loose dry sand from the shore, to form the downs, would necessarily continue to drift that which is at the summit further towards the land. On the east coast of Scotland, and in many of the islands, there are striking effects of this kind. De Luc, the brother, in the *Mercure de France*, communicates the following interesting statement in regard to the progress of the blowing sand, termed the *sand flood* in Egypt:

"The *sands* of the Lybian desert," he says, "driven by the west winds, have left no lands capable of tillage on any parts of the western banks of the Nile not sheltered by mountains. The encroachment of these *sands* on soils which were formerly habited and cultivated is evidently seen. M Denon informs us, in the account of his *Travels in Lower and Upper Egypt*, that summits of the ruins of ancient cities, buried under these *sands*, still appear externally; and that, but for a ridge of mountains called the *Lybian chain*, which borders the left bank of the Nile, and forms, in the parts where it rises, a barrier against the invasion of these *sands*, the shores of the river, on that side, would long since have ceased to be habitable. Nothing can be more melancholy," says this traveller, "than to walk over villages swallowed up by the sand of the desert, to trample under foot their roofs, to strike against the summits of their minarets, to reflect that yonder were cultivated fields, that there grew trees, that here were even the dwellings of men, and that all has vanished.

"If then our continents were as ancient as has been pretended, no traces of the habitation of men would appear on any part of the western bank of the Nile, which is exposed to this scourge of the *sands* of the desert. The existence, therefore, of such monuments attests the successive progress of the encroachments of the sand; and these parts of the bank, formerly inhabited, will for ever remain arid and waste. Thus the great population of Egypt, announced by the vast and numerous ruins of its cities, was in great part due to a cause of fertility which no longer exists, and to which sufficient attention has not been given. The *sands* of the desert were formerly remote from Egypt; the Oases, or habitable spots, still appearing in the midst of the sands, being the remains of the soils formerly extending the whole way to the Nile; but these *sands*, transported hither by the western winds, have overwhelmed and buried this extensive tract, and doomed to sterility a land which was once remarkable for its fruitfulness.

"It is therefore not solely to her revolutions and changes of sovereigns that Egypt owes the loss of her ancient splendour; it is also to her having been thus irrecoverably deprived of a tract of land, by which, before the sands of the desert had covered it and caused it to disappear, her wants had been abundantly supplied. Now, if we fix our attention on this fact, and reflect on the consequences which would have attended it if thousands, or only some hundreds of centuries had elapsed since our continents first existed above the level of the sea, does it not evidently appear that all the country on the west of the Nile would have been buried under this *sand* before the erection of the cities of ancient Egypt, how remote soever that period may be supposed; and that, in a country so long afflicted with sterility, no idea would even have been formed of constructing such vast and numerous edifices? When these cities indeed were built, another cause concurred in favouring their prosperity. The navigation of the Red Sea was not then attended with any danger on the coasts; all its ports, now nearly blocked up with reefs of coral, had a safe and easy access; the vessels laden with merchandize and provisions could enter them and depart without risk of being wrecked on these shoals, which have risen since that time, and are still increasing in extent.

"The defects of the present government of Egypt, and the discovery of the passage from Europe to India round the Cape of Good Hope, are therefore not the only causes of the present state of decline of this country. If the *sands* of the desert had not invaded the bordering lands on the west, if the work of the *sea polypi* in the Red Sea had not rendered dangerous the access to its coasts and to its ports, and even filled up some of the latter, the population of Egypt and the adjacent countries, together with their product, would alone have sufficed to maintain them in a state of prosperity and abundance. But now, though the passage to India by the Cape of Good Hope should cease to exist, though the political advantages which Egypt enjoyed during the brilliant period of Thebes and Memphis should be re-established, she could never again attain the same degree of splendour.

"Thus the reefs of coral which had been raised in the Red Sea on the east of Egypt, and the *sands* of the desert which invade it on the west, concur in attesting this truth: That our continents are not of a more remote antiquity than has been assigned to them by the sacred historian in the book of Genesis, from the great era of the Deluge."

Sea-salt affords us examples of *the chemical forming* effect of water, as is exemplified in the lakes of the Tauride, in Southern Africa, and many other places. We there observe beds of salt formed by precipitation from the waters of the lakes; and sometimes these beds alternate with others of clay and loam, and vary much in their degree of inclination. Bog iron-ore, which is forming daily, is another example of the same kind of formation. Morass-ore sometimes alternates in beds with peat; and swamp-oar sometimes occurs in thin beds, covering the more compact kinds of peat. Peat itself may be ranked as one of the substances formed by chemical agency.

The vast accumulations of calc-sinter found in limestone caves, as in those of Derbyshire, the Hartz, the Fichtelgebirge, Antiparos, Gibraltar, &c. belong also to the chemical formations. Calc-sinter is found usually in inclosed spaces, whereas calc-tuff is formed in open spaces. This substance is deposited sometimes in caves, and frequently in fissures, forming veins, which are in this manner filled with very compact calc-sinter, and sometimes even with crystallized calc-spar. Calc-tuff is formed by calcareous brooks emptying themselves into hollows, and thus affording an opportunity for the deposition of their calcareous contents. Near Canstadt in Wurtemberg, streams of this kind incrust every thing in their vicinity with calc-tuff, which approaches more or less to calc-sinter. If such streams flow into situations where the water has repose and time to deposite its calcareous contents, calcareous beds or strata are formed, which are more or less porous. This porosity is increased on the land, by the tuff mixing with reeds and grass. In beds of this substance skeletons of extinct quadrupeds are met with.

Destroying and forming effects of Volcanoes.

The operation of volcanoes is still more limited and local than that of water. Although we are entirely ignorant of the means employed by nature in producing volcanic fire, we can judge by its effects of the changes it is capable of producing upon the surface of the earth. When a volcano announces itself after some shocks of an earthquake, it forms for itself an opening. Stones and ashes are thrown to a great distance, and lava is vomited forth. The more fluid part of the lava runs in long streams, while the less fluid portion stops at the edge of the opening, raises it all round, and forms a line terminated by a crater. Thus volcanoes accumulate substances on the surface that were formerly buried deep in the bowels of the earth, after having changed or modified their nature or appearances, and raise them into mountains. By these means, they have formerly covered some parts of the continents, and have suddenly produced mountains in the middle of the sea. But these mountains and islands have always been composed of lava, and the whole of their materials have undergone the action of fire. Volcanoes have never raised up or overturned the strata, through which their apertures pass, and have in no degree contributed to the elevation of the great mountains which are not volcanic.*

CHAP. III.

INTERNAL STRUCTURE OF THE EARTH.

Having in the preceding Chapters described the various inequalities observable on the earth's surface, and stated the means which nature appears to have employed in forming them, we come now to the consideration of the second branch of Geognosy, which makes us acquainted with the *internal structure* of the earth.

At first sight the solid mass of the earth appears to be a confused assemblage of rocky masses piled on each other without order or regularity: to the superficial observer, nature appears, in the apparently rude matter of the inorganic kingdom, to present us as only with a picture of chaos, where none of those admirable displays of skill and contrivance, which, in the structure of animals and vegetables, so powerfully excite our attention, and claim our admiration, are to be observed. It is not surprising that this unfavourable opinion should have long continued to be prevalent, when we consider the experience, skill and judgment, which are necessary for enabling us to unravel all the variety of apparently unconnected relations, which are observable in the internal structure of the earth. In ancient writers we find nothing on this important subject; and it is only by the light of modern discoveries, that we have been enabled to trace out those beautiful arrangements that prevail in the mineral kingdom. Of these, we shall now give a concise and accurate description, and at the same time state some of those inferences that appear to be deducible from these various relations and appearances. But these descriptions and inferences can only be fully understood, and the gratification derived from them completely enjoyed, by an intimate acquaintance with nature herself, not in cabinets alone, but in mines and among mountains. On descending into mines, we are not only gratified by displays of human ingenuity and skill, but we also receive much information respecting the structure of the earth, and the changes it has experienced during the different periods of its formation. Our researches on the surface of the earth, on the other hand, often leads us among the grandest and most sublime

* Cuvier's *Theory of the Earth.*

works of nature; and amid alpine groups, the geologist is, as it were, conducted nearer to the scene of those great operations, which it is his business to explore. In the midst of such scenes, he feels his mind invigorated; the magnitude of the appearances before him extinguishes all the little and contracted notions he may have formed in the closet; and he learns, that it is only by visiting and studying these stupendous works, that he can form an adequate conception of the great relations of the crust of the globe, and of its mode of formation.

Nature appears, in her formations, frequently to proceed from the most special to the most general; or, we observe the most general, including a series of gradually diminishing subordinate differences. In simple minerals, many instances of this occur, as in the distinct concretions, fracture, and external surface. But it is more strikingly the case in the structure of the crust of the earth, for here there is a series from that of the simple mountain rock to those grand and extensive arrangements in the formations that form whole mountains and chains of mountains.

Four different kinds of structure are observable in the crust of the earth.—The *first* is, that which is to be observed in hand specimens; it is the smallest kind of structure, and occurs in what are termed *Mountain Rocks* or *Stones*.—The *second* kind of structure, or that of *Mountain Masses*, is more on the great scale, and is not to be observed in hand specimens, but only in single masses of rock. To this structure belongs stratification, and the seams of distinct concretions.—The *third* kind of structure is that of *Rock Formations*, or those great masses of which the crust of the earth is composed. To examine this kind of structure, we must traverse considerable tracts of country.—The *fourth* kind of structure is that of the *Earth* itself, which is formed by the junction of various formations. To examine this structure, we must travel through many countries.

We have thus a geognostic series of structure from hand specimens, which can be examined in the closet, to that which can only be known by travelling through many countries.

We shall now describe the different kinds of structure, in the order already mentioned.

Structure of Mountain Rocks.

Mountain Rocks or Stones, are those mineral masses of which the greater portion of the crust of the earth is composed. Minerals, or mineral aggregates, to have the true characters of mountain rocks, must occur not only in great masses, but frequently, and present in their structure and composition such characters as will serve to distinguish them, and make them known in whatever situation they may be found.

They are either simple, or aggregations of simple minerals. In the one case, they are denominated *Simple mountain rocks*; in the other, *Compound mountain rocks*.

Simple mountain rocks are either compact, slaty, or granular. Clay-slate, limestone, and serpentine are examples of simple mountain rocks.

When minerals occur disseminated through simple mountain rocks, they are to be considered as accidental, and do not entitle us to consider such varieties as distinct species of rock. Thus garnets, imbedded in granite or mica-slate, are accidental mixed parts.

Compound mountain rocks are either *conglomerated* or *aggregated*. This distinction is founded on the mode of their formation. The grains or masses in the conglomerated mass, according to some naturalists, have not been formed on the spot where they are now found, but have been carried thither, and connected together by a cement. To this class belongs sandstone, puddingstone, and different kinds of fragmented or brecciated stones.*

In *aggregated mountain rocks* or stones, their present structure is their original one, and the parts of which they are composed have been formed on the spot where we now find them. Their parts are immediately connected together; hence this structure is termed *aggregated*.

Aggregated mountain rocks are either *determinately* or *indeterminately* aggregated. The parts in the *indeterminately aggregated*, are irregularly and confusedly joined together. This kind of structure occurs in those varieties of serpentine, where limestone and serpentine are so conjoined that it is difficult to say which predominates, and where the one sometimes encloses the other. The Campan marble, which is an irregular mixture of limestone and steatite, and many Cipolin marbles, which contain veins and patches of green talc, are of the same description.

The *determinately aggregated structure*, presents a number of subordinate differences. It is either *simple* or *double* aggregated. The *simple aggregated* contains two subordinate kinds. In the *first*, the minerals are connected together in such a manner that one serves as a basis for the other, which is included in it; and it also contains two subordinate kinds. These are denominated the *porphyritic* and *amygdaloidal*. In the *second*, all the parts are immediately connected, or joined together; and here we have also two subordinate kinds, the *granular* and *slaty*.

The *double aggregated* includes five subordinate kinds: These are, 1. *Granular slaty*. 2. *Slaty granular*. 3. *Granular porphyritic*. 4. *Slaty porphyritic; and*, 5, *Porphyritic and amygdaloidal*. The first four kinds of double aggregated structure comprehend one structure in another, so that, as the denominations intimate, a smaller structure is contained in a greater. In the fifth, or last kind, one does not include the other; but, as the denomination expresses it, they are placed near or beside each other.

We shall now describe each kind in particular.

Simple Aggregated Structure.

1. *Porphyritic structure.*—When one of the constituent parts of the mountain rock is disseminated through a basis, in the form of grains or crystals, the rock presenting this appearance is said to be *porphyritic*. Common porphyry, porphyry slate, and gypsum containing crystals of quartz, may be mentioned as examples of this kind of structure. The crystals or grains are here of cotemporaneous formation with the basis, and not mechanically mixed, as some have maintained.

2. *Amygdaloidal structure.*—When vesicular cavities are dispersed through a basis or ground, and appear

* We shall afterwards examine particularly the above, which is the general opinion, in regard to the formation of conglomerated rocks.

empty, encrusted, half filled, or completely filled, such a structure is denominated *amygdaloidal*.

The rock named amygdaloid, is a principal example of this kind of structure. Its basis approaches more or less to basalt or greenstone; when it is much iron-shot, it becomes harder and more solid. It is alleged, that while the amygdaloidal rock was still soft, bubbles of air were disengaged, which being prevented escaping by the viscosity of the mass, various shaped cavities, often however of an amygdaloidal shape, were formed. Water holding in solution the various minerals met with in these amygdaloids, is alleged to have traversed the rock, penetrated into the empty vesicular cavities, and to have deposited on their walls its mineral contents. Hence it is maintained, that the amygdaloidal portions are of posterior origin to the basis in which they are contained. It cannot be questioned, that some amygdaloidal structures have originated in this manner, but many others are certainly of cotemporaneous formation with the rock in which they are contained. The minerals that usually occur in these vesicles, are lithomarge, zeolite, steatite, chalcedony, agate, heavy spar, and calc-spar. Those filled with agate and chalcedony, present many interesting phenomena.

3. *Granular structure.* In aggregated rocks, some kinds are formed by the immediate aggregation of different minerals, which are intimately joined together, either by the power of cohesion, or by mutual penetration or interlacement. These minerals are generally in grains, and may be regarded as imperfect crystals. Granite affords an example of this kind of structure.

4. *Slaty structure.*—The slaty structure in rocks composed of different minerals differs from the granular in this circumstance, that the constituent parts are flat, having considerable length and breadth, but inconsiderable thickness. Mica slate, which consists of small plates of quartz and small plates of mica placed upon each other, is an example of this kind of structure.

Double Aggregated Structure.

Under this head we include those varieties where two structures occur together. The following are the different kinds.

1. *Granular-slaty structure.*—Gneiss affords a good example of this kind of structure; the granite and felspar are in grains, and immediately aggregated together, which forms the granular structure; and these aggregations are generally disposed in plates, which are interposed between the plates of mica, and hence the slaty structure.

2. *Slaty-granular structure*—Is slaty in the small, and granular in the great. The only example of this kind of structure is the topaz-rock of Schneckenstein, in Voightland, in the electorate of Saxony. It is composed of large granular masses, which have a slaty structure; the slates consist of fine granular quartz, thin columnar schorl, and small granular topaz. In the drusy cavities that occur between the large granular concretions, lithomarge, crystals of topaz, and schorl, sometimes occur; the schorl, however, is but rarely crystallized.

3. *Granular-porphyritic structure.*—This kind of structure is granular in the small, and porphyritic in the great. When large and distinct crystals of felspar appear dispersed through a granular base, as is often the case with granite, sienite, and greenstone, this kind of structure is formed.

4. *Slaty porphyritic.*—This kind of structure is slaty in the small, and porphyritic in the great. The basis is slaty, and the porphyritic structure is formed by interspersed crystals or grains of minerals different from the basis. Mica-slate, when it contains grains or crystals of garnet is said to have a slaty-porphyritic structure.

5. *Porphyritic and Amagdaloidal.*—Here two kinds of structure are placed together, not included in each other, as in the preceding kinds. It occurs in many amygdaloidal and porphyritic stones. When amygdaloid contains, besides the elliptical-shaped masses, also crystals of hornblende and mica, it is then said to have an amygdaloidal and porphyritic structure; the amygdaloidal being the predominant. In Basalt, on the contrary, where the two kinds of structure sometimes occur, the porphyritic is the predominating. Green Porphyry, although rarely, sometimes possesses this kind of double structure.

Table of the Structure of Mountain Rocks.

Structure of Mountain Stones or Rocks.

- A. Compound,
  - a. Conglomerated, — Sandstone. Puddingstone. Different fragmented stones.
  - b. Aggregated,
    - α. Determinate,
      - a. Double,
        - I. Granular-slaty, — Gneiss.
        - II. Slaty-granular, — Topaz-Rock.
        - III. Granular-porphyritic, — Granite. Sienite. Greenstone.
        - IV. Slaty-porphyritic. — Mica-slate.
        - V. Porphyritic and Amygdaloidal, — Amygdaloid. Basalt. Green-Porphyry.
      - b. Single.
        - I. With a basis,
          - 1. Porphyritic, — True Porphyry. Green Porphyry. Porphyry Slate. Porphyritic Basalt. Gypsum.
          - 2. Amygdaloidal, — Different kinds of Amygdaloid.
        - II Aggregated,
          - 1. Granula, — Granite. Senite. Greenstone.
          - 2. Slaty, — Mica-Slate.
    - β. Indeterminate, — Serpentine with Limestone.
- B. Simple. — Limestone. Gypsum. Serpentine. Clay Slate. Quartz-Rock. Flinty-Slate.

Structure of Mountain-masses and of Strata.

We understand by the structure of mountain masses, those regular divisions which many of them exhibit through a considerable extent of rock. There are two kinds of this structure; the stratified structure, or that of strata; and the seamed structure, or that of distinct concretions.

Stratified structure.—When a mountain, mountain-mass, or bed composed of one species of rock, is divided by means of parallel seams into masses, whose length and breadth are greater than their thickness, or into what may be denominated Tabular Masses, which extend generally through the whole mountain, it is said to be stratified, and the individual masses are termed strata. Of this kind of structure we have instances in Granite. Limestone, Clay-slate, and Mica-slate. The seams that separate the strata are named strata-seams, or seams of stratification. On a general view, we say the globe is composed of formations; formations of beds; beds of strata; and such strata as are slaty, of layers, or slates.

Strata vary very much in their position. The examination of this appearance of strata is of great importance to the geognost and mineralogical geographer.

In determining the stratification of a rock, we have to observe, 1. The direction of the strata. 2. Their inclination. 3. Their thickness. 4. The differences in their direction and inclination.

The direction is the angle which the stratum makes with the meridian, and is determined by the compass; or viewing the strata as planes, the direction is that of a horizontal line, drawn on the surface of the plane; therefore, to determine the direction, is to indicate the point of the compass towards which this line is directed. It is always at right angles to the dip.

The inclination is the angle which the stratum forms with the horizon, and is determined by the quadrant.

The dip is the point of the compass towards which the stratum inclines. If we know the dip, the direction is given, because it is always at right angles to it. Thus, if a stratum dip to the east, its direction must be north and south; if it dip to the north, its direction must be east and west. But we cannot infer the dip from the direction; because a stratum, whose direction continues the same, may dip in opposite directions; thus, a stratum ranging from north to south may dip either to the east or to the west.

Strata are frequently variously waved, thus producing changes in their direction; but these changes in direction are, in general, subordinate to the general direction. It is therefore of importance, in making observations with regard to the position of strata, to distinguish the *general direction* and inclination, from the *partial*. To effect this, we must take the results of a number of particular observations, and compare them together; and those similar angles, which are the most numerous, are to be considered as expressive of the general inclination and direction. It sometimes happens, that this general position has also its variations; these must also be attended to and noted. An acquaintance with the shape of a mountain group will assist us very much in such investigations, as it is intimately connected with the general disposition of the stratification of the masses of which it is composed. It is also of importance to know the fall or declivity of a mountain group, as its direction and inclination are frequently conformable, particularly in the older formations, with that of the superimposed masses.

It is often very difficult to determine, whether the rock we are examining be stratified or not, and when the seams of stratification are hid, to know the direction of the strata. The following observations will be useful in removing some of the difficulties attending such investitions.

1. Strata are almost always parallel with the slaty structure of the stone. In certain porphyritic granites, the crystals of felspar appear to lie parallel with the strata; the latter character, however, is by no means so decisive as the former.

2. Strata can only be formed by parallel seams, which have the same direction and extent through the mountain-mass. Where parallel rents occur in different directions in the same species of rock, as in granite, sandstone, lime-stone, &c. it is evident that they are to be considered as accidental.

3. The seams of tabular distinct concretions, which are often of considerable extent, should not be confounded with strata seams, because their extent is not so considerable; and in each group of concretions the direction is different.

4. Where parallel rents have a different direction from the slaty structure of the stone, they are certainly accidental. Inattention to this circumstance has led mineralogists into error. I observed a striking instance of these rents in a quarry of gneiss, in the forest of Tharand, in Upper Saxony. The gneiss, at first sight, appeared to be disposed in vertical strata, and as such it was viewed by De Luc: on a closer examination, however, the apparent vertical seams proved to be merely accidental parallel rents, perpendicular to the slaty structure of the stone; therefore the strata were horizontal, not vertical.

5. Beds are generally parallel with the strata; these, therefore, point out the direction of the strata.

6. Although the slaty structure points out to us the direction which the strata must have, it does not follow, that a rock having a slaty structure is stratified.

7. In sand-stone, lime-stone, and rock-salt, regular and very extensive stripes are sometimes observed, which have been confounded with true seams of stratification. An attentive examination, however, always discovers them traversing the real strata seams. Von Buch, in his description of Landeck, and geognostical observations made in Italy and Germany; and Friesleben, in his observations on Thuringia, describes striking instances of stripes resembling strata-seams.

Strata vary very considerably in the angle which they form with the horizon; they occur from horizontal to vertical, but the general inclination is between horizontal and 45°. The differences are either original, or have been produced by subsequent changes.

Certain species of rock are constantly stratified, while others either are not stratified, or only in an imperfect manner. All the secondary rocks, such as lime-stone, sand-stone, coal, &c. are very distinctly stratified. In the most modern of the secondary rocks, the strata are often horizontal, and frequently extend to a great distance of the same thickness. In more ancient rocks of this class, as in certain lime-stones and in gypsum, the stratification is less distinct, and the position of the strata is not so horizontal. In the coal formation, which is of a still older date, the stratification is very distinct, but the beds are frequently variously waved and convoluted, and often highly inclined. In the transition and primitive classes, many rocks, such as gneiss, mica-slate, and clay-slate, are distinctly stratified, while others, as granite, porphyry, trap, limestone, gypsum, serpentine, and quartz, are in general but imperfectly stratified, and the strata of these two classes more often incline to the vertical than to the horizontal position.

Rocks which appear to have been mere deposites of mud, gravel, sand, &c. have been formed by successive depositions, while others, such as gypsum, limestone, quartz, gneiss, mica-slate, clay-slate, granite, &c. owe their stratified structure to crystallization, from a more or less perfect state of solution. This latter opinion is illustrated by the uninterrupted transitions of the beds into each other, and by the position of the embedded crystals and masses to the surrounding rock.

On examining the structure of a mountain or tract of country, we must be careful to avoid all unnecessary minuteness, otherwise we shall fail in acquiring a distinct conception of it. This observation is founded on a knowledge of the geognostical features of nature, which are all on the great scale.

By not attending to this mode of examination, geologists have fallen into errors, and given to extensive tracts of country a most irregular and confused structure. Speculators, building on these errors, have represented the whole crust of the globe as an irregular and unseemly mass. It is indeed surprising, that men possessed of any knowledge of the beautiful harmony that prevails in the structure of organic beings, could for a moment believe it possible, that the great fabric of the globe itself,—that magnificent display of Omnipotence,—should be destitute of all regularity in its structure, and be nothing more than a heap of ruins.

Seamed Structure.—Those rocks in which parallel seams occur, that do not extend throughout the whole bed, are said to have the *seamed structure*. The following are the different kinds of this structure: 1. Polyedral. 2. Lamellar. 3. Globular.

1 *Polyedral.*—In this kind of structure, the rock is divided into columns. The columns are sometimes regular, sometimes approach to the globular form, and occur even curvated. They are from a few inches to many fathoms in length. In the islands of Staffa and Eigg, and on the Craig of Ailsa, there are admirable examples of this kind of structure. These columns are sometimes collected into groups, and such groups are often separated from each other by seams, or rather rents, which render them more distinct. Such groups may be considered as immense distinct concretions. The columns of such a group often tend towards a centre; others are parallel or perpendicular; some are horizontal; and all this variety sometimes occurs in the same hill. The columns are sometimes jointed, so that the convex extremity of the one column is fitted to the concave extremity of the other; and these columns are usually composed of globular distinct concretions. These globular concretions are composed of curved lamellar concretions. The spaces between the different globular concretions are composed of a looser matter than the concretions themselves; and it is by the falling out of this less compact substance that the structure of such columns is first developed.

No rock shows this kind of structure more distinctly than basalt: in it we have all the varieties of the seamed structure, from the smallest, which is the lamellar distinct concretion, to the largest, which is formed by the grouping of columns.

This kind of structure occurs also in porphyry, greenstone, and lava.

2. *Tabular.*—In this kind of structure, the rock is divided into tables a few inches thick, and of small extent. These tables frequently change their direction, and then the bed of rock is divided into many groups or systems of tables, having in each group a different direction.

Their inconsiderable length, frequent change of direction, and the even surface of the planes, distinguish them from strata. Basalt, in the lower parts of an individual deposition, has often this kind of structure. At first sight it is not unlike stratification. It also occurs in columnar porphyry.

3. *Globular.*—In this kind of structure the rock is either wholly or partially disposed, or arranged into globes or balls of various magnitudes. These balls are either simply granular, as in granite, syenite, greenstone, or sand-stone; granular, and lamellar, as in the syenite of Corsica; compact, as in basalt; porphyritic, as in porphyry; or radiated, as in limestone. Globular formations are sometimes met with in rocks and minerals having a less crystalline aspect. As examples, we may mention balls of hornstone in limestone, and masses of flint in chalk.

The roundish balls of granite found dispersed over low countries have been considered as bowlder or rolled stones, and many theories formed to account for their transportation. The granite of the island of Arran presents this kind of structure.

Structure of Formations.

By a *Rock formation*, we understand a determinate assemblage of similar or dissimilar beds or rock masses, which are characterised by external and internal relations as an independent whole; that is, as an unity in the series of rock formations. These masses are either *simple* or *compound*. When the mass is uniform throughout, as is the case with limestone or sandstone, it constitutes what may be denominated a *simple formation*. Granite, gneiss, and mica-slate, are also of this kind. When dissimilar masses occur in a formation, as in the case of coal and secondary trap, it is said to be a *compound formation*.

Similar rocks are often repeated in very different periods. Each of these individual depositions is a particular formation, and the whole is denominated a *series* or *suit of formations*. Thus there is a limestone, a porphyry, a granite suit, &c.

It is, Werner remarks, a determinate character of certain formations, to constitute the principal mass of the mountain in which they occur: this is the case with gneiss, clay-slate, porphyry, and others. With other formations, on the contrary, it is as essential a character to occur only in single beds in the others, and these are said to be imbedded. Primitive porphyry, limestone, and many others, are of this kind. When such individual beds occur in different principal formations, (that is, are not confined to a single one,) as primitive limestone and primitive trap in gneiss, mica-slate, and clay-slate, and always continue the same, notwithstanding the difference of the rocks in which they are embedded, they are to be considered as *independent formations*. If, on the contrary, they are confined to one formation, and are connected with no series or suite of formations, they are said to be *subordinate* to it. Alum, slate and Lydian stone n clay-slate, are examples of this kind. Beds comp sed of various minerals sometimes occur in different rocks. These minerals are usually those of which the rock is principally composed, irregularly mixed, or are simple minerals. Such beds are usually very irregular, do not extend through the whole rock, and in general exhibit apparently great irregularity in all their relations. They have been, but rather improperly, denominated *foreign beds*. When single beds are well distinguished by the kind of stone of which they are composed, and if their composition shows certain peculiarities, (as, for example, the determinate presence of metallic fossils, &c.) they are referred to the *particular repositories*. Beds of iron-pyrites and magnetic ironstone are of this kind.

Structure of the Crust of the Globe.

The fourth and last kind of structure we have to describe is by far the most extensive and important. It is the structure of the crust of the globe itself, in so far as it is composed of rock-formations of different magnitudes, laid over each other in certain directions.

Under the five following heads, Werner comprehends every relation respecting the extent and relative position of formations in general.

1. The original extent of formations.
2. Their present extent and continuity.
3. The position and direction of the strata of formations, in respect to the fundamental rock.
4. The direction of the strata themselves, without reference to the fundamental rock.
5. The relation of the outgoings of the strata to the exterior of the mountain.

It may be previously remarked, that when one formation lies on another, it is said to *rest* on it, and the rock on which it rests is termed the *fundamental* rock; and the plane which separates the fundamental rock from the formation that covers it, is denominated the *plane of separation*, which is always parallel with the seams of the strata. See Plate CCCXCV. Fig. 1.

1. *The Original Extent of Formations.*

Werner observes, that the greater number of formations appear to have been very widely deposited; and these he denominates *Universal Formations*. Some others he considers as having been partially deposited, and these he terms *partial* or *anomalous formations*.

Universal Formations extend around the whole globe, (not, however, without interruption.) and constitute by far the greater part of the mass of which its crust is composed. Almost all the primitive transition, and secondary formations, are universal depositions; of these, we may mention granite, gneiss, porphyry, and limestone.

Partial formations occur only in particular places, and appear to owe their existence to particular and local causes, for example, to depositions in lakes. Lamanon is of opinion, that the gypsum formation around Paris was formed from the waters of a lake which formerly occupied that part of France; and the extensive local formation in the Isle of Wight, and the opposite coast of England, appears also to be a lake formation. At Wehraw, in Lusatia, there is an example of a partial formation. It consists of sandstone, limestone, bituminous-shale, and iron-clay; and these rest on loose sand. The sandstone resembles, in many respects, that found in other sandstone formations; yet it does not belong to any of them, as is evident from its position, and the rocks with which it is associated. Werner conjectures that it may have been formed by a small and partial flood.

The examination of these partial appearances is of much importance, not only in extending our knowledge of the variety of formations, but in connecting the history of the earth more nearly with that of man.

2. *The Present Extent and Continuity of Formations.*

The present extent and continuity of formations is very different from what it was originally. We find them either extended uninterruptedly over great tracks of country, or they appear isolated, of little extent, and frequently resembling partial formations. In the one case, they are said to be *unbroken*, in the other *broken*. The broken formations occur in small detached masses; and these have peculiar denominations, according to their position and shape.

When detached portions occur on the summits of hills, these are called *caps*, Fig. 2. *a*. When portions occur, filling up hollow spaces between mountains, they are denominated *upfillings*, Fig. 2. *b*. And when a portion occurs only on one side of a mountain, it is said to be *shield formed*, Fig. 2. *c*. or to have the shape of a shield.

3. *The Position and Direction of Strata in regard to the Fundamental Rock.*

When strata have the same direction as the fundamental rock, they are said to be *conformable* with it, Fig. 3. *a*. if the direction is different, they are said to be *unconformable*. If they differ only in direction, we say that they are *simply unconformable*, Fig. 3. *b.*; but if they differ not only in direction, but lie over the ends of the strata of the fundamental rock, they are said to be *unconformable and overlying*, Fig. 3. *c*. Overlying strata occur more frequently than simply unconformable, and have far greater extent.

4. *Direction of the Strata themselves, without reference to the Fundamental Rock.*

Strata are either *straight*, that is, disposed in one direction on the fundamental rock, Fig. 4. or they turn around it, and inclose it; in this latter case they are said to be *mantle formed*, or *mantle-shaped*, Fig. 5. *b*. If the strata are not only wrapped around the fundamental rock, but also cover its extremities, they are said to be *saddle-shaped*, Fig. 6.

When the upper part of the saddle-shape is carried away, the *mantle-shape* is formed.

Strata are sometimes concave, and they are then said to be *basin-shaped*, Fig. 7. *a.*; Fig. 10. but if the concavity be oblong, they are named *trough shaped*, Fig. 8 *b*. In the concave, that is, the basin and trough-shaped, and in the convex, that is, the saddle and mantle-shaped strata, the *outgoings** form circles: in the concave, the outer and greatest circle, according to Werner, is

* By the *outgoings* of the strata are understood their upper extremities, as they appear at the surface of the earth. Fig. 59.

the oldest; in the convex, on the contrary, the outer and largest circle is considered to be the newest.

5. *The Relation of the Outgoings of the Strata to the Exterior of the Mountain.*

We have to consider first, the relation of the outgoings of strata to mountain-masses of considerable extent; and, secondly, to mountain caps.

In mountain-masses, the strata either cover each other completely, or the outgoings are open and exposed. When the outgoings are exposed, the newer strata have a *rising* or *sinking level*, Fig. 9.

There are three different kinds of *mountain-caps*: In the *first*, the cap rests on a fundamental rock, the seams of the strata are parallel with the plane on which the strata rest, and these are unconformable and overlying, Fig. 10. *a*. The *second* kind of cap is formed by a rock rising through the surrounding strata, Fig. 11. *b.*: and the *third* kind of cap is formed by portions of harder beds remaining after the superincumbent and adjacent and softer strata have been carried away, Fig. 12. *c*.

In the *first*, the rock is unconformable and overlying. The secondary-trap and porphyry formations afford numerous examples of this kind of mountain-cap.

In the *second*, the newer strata are mantle-shaped. Granite often occurs in caps of this kind.

In the *third*, all the strata are conformable, so that the subjacent and superincumbent strata have the same direction with the bed which forms the cap. Primitive greenstone in clay-slate, sometimes forms caps of this kind.

CHAP. IV.

ON THE FORMATION OF ROCKS, AND ON FORMATIONS.

Having now described the different kinds of structure which occur in the crust of the earth, we shall next treat of the formation of mountain rocks, and of the revolutions which the earth is alleged to have experienced during its formation. But those revolutions are of a different nature from the effects now produced on the surface of the earth; and therefore the speculations in regard to them are to be considered more interesting on account of the facts they bring to light, than from any intrinsic merit they themselves possess. The most ingenious of these speculations respecting the formation of the earth, hitherto proposed, is that of Werner; and the following statement will, we think, convey to our readers a distinct account of it.

The spheroidal figure of the earth, its crystalline and stratified structures, and its numerous petrifactions, are proofs of its original fluidity. The fluidity, according to Werner, was aqueous; and he conjectures that the various rocks were originally suspended or dissolved in water, and gradually deposited from it.

In chapter second, when mentioning the effects of water on the surface of the globe, we described several mechanical and chemical depositions which are daily taking place, as it were, under our eye; and as these present the same kind of structure that occurs in mountain rocks, Werner infers these also to have been formed by the same agent. As the highest mountains are composed of rocks, possessing a structure resembling those fossils which have been formed by water, we naturally conclude, that the ocean must have formerly stood very high over these mountains. Further, as the most elevated mountains are composed of rocks, such as granite, gneiss, mica-slate, clay-slate, and others, which extend around the whole globe, and have been formed during the same period of time, it follows, that the ocean must have *formerly covered the whole earth at the same time*.—The former great height, and the present low level of the waters of the globe, is so remarkable a phenomenon, that it gave rise to many very opposite hypotheses, as soon as it attracted the attention of observers. We shall notice a few of these speculations.

It has been supposed, that the water has suffered a translocation, by a complete alteration of the terrestrial poles and equator. This hypothesis, however, is unsupported by fact, as no traces are to be found of so vast a change. The difference between the equatorial and polar diameters, the accumulation of high land around the equator, are proofs that the present poles and equator are the original ones. Even allowing that such a change had taken place, it is evident that the greatest possible alteration of the earth's axis could cause no uncovering of it, as the water stood high over the whole globe.

Another opinion was proposed by De Luc, La Metherie, and others; namely, that the water had retired into immense caverns, situated towards the centre of the earth. From the description already given of the internal structure of the earth, it is evident that the existence of such caverns is imaginary, and totally irreconcileable with the notion of precipitation from a state of solution. Allowing, for a moment, the possibility of their existence, is it not evident, not only that the water would have rushed into them with such violence as to leave the most marked traces of its effects on the surface of the earth, but that the places where the water entered would still be discoverable?

The most probable explanation is that of the gradual diminution of the water from the surface of the earth. It was first obscurely hinted at by Herodotus, Strabo, and other ancient writers. Maillet, French consul at Alexandria, in a work entitled *Telliamed*, published in 1740, was the first in modern times who directed the attention of philosophers to the theory of the diminution of the waters of the globe. This opinion was eagerly adopted, and keenly supported by Linnæus, Celsius, and other Swedish naturalists. They collected many facts, to show that the waters of the Baltic are diminishing; and the scholars of Linnæus observed many similar appearances in other countries. Of these, many interesting instances are detailed in the writings of Pallas, Gmelin, Ferber, Niebuhr, Vancouver, Peron, and others. Even although all these proofs were wanting, it is evident that, if the water remained unaltered in quantity, it would rise and overflow its boundary, owing to the great quantity of earthy matter which is daily carried into it by rivers and streams. This opinion, as supported by Linnæus and several others, met with considerable opposition. Many facts were brought forward, to show, that while the land is left by the sea in one place, it is invaded in an equal proportion in another; and consequently that there is no diminution of the water. The invasion of the land by the sea is, however, a comparatively rare occurrence; and besides, these partial elevations of the water depend on particular circumstances, which can in general be pointed out. Thus, the change in the direction of currents, produced by the accumulation of water by winds, the alteration of the shape of coasts, and many other causes, produce alterations in the level of the ocean.

Werner, with his usual acutenes, soon discovered that the documents for the illustration of this supposed phenomenon were not to be sought for in the formations that have taken place within the limits of human history, but in the *solid strata* of which the crust of the earth is composed. His investigations led him to the following observations: 1*st*, That the outgoings of the newer strata are generally lower than the outgoings of the older, from granite downwards to the alluvial depositions, and this not in particular spots, but around the whole globe. 2*d*, That the primitive part of the earth is entirely composed of chemical precipitations, and that mechanical depositions do not appear until a later period, that is, in the Transition class; and that from this point they continue increasing, through all the succeding classes of rocks, to the newest or the alluvial, which are almost entirely mechanical deposits. These observations, in his opinion, illustrate the universal diminution of the waters of the globe. The sinking of the level of the outgoings of the newer and newer strata, he continues, shows that the solution from which they were formed must have experienced a similar change; that is, it must have diminished in height, and that not in one spot, but around the whole globe. Hence the water which once covered the whole globe to a great height must have diminished universally.

The period of the occurrence of mechanical depositions is a further proof of the diminution of the water. We find, that in the earliest periods chemical productions only were formed, owing to the high and universal submergence. It is evident, that when the earth was covered to a great height with water, no mechanical deposits could be formed; for it is well known, that the motion communicated to water does not reach to a great depth. Mechanical deposits would, therefore, be first formed, as soon as part of the solid mass of the earth appeared above the level of the water, or when the surface of the water approached so near to that of the earth, that it could act on it mechanically. Hence, as soon as the higher parts of the earth rose above the surface of the water, mechanical depositions would increase; and we find, accordingly, an increase of mechanical deposition, corresponding to the diminishing level of the ocean, from the transition to the newest period. It follows, that as these alterations have been universal, extending around the whole globe, the level of the water has changed uniformly and universally, and that it has sunk by degrees to its present level.

Several other interesting phenomena, which we have already mentioned in part, strengthen and illustrate more fully the preceding conclusions. Petrifactions, we know, first occur in formations of a middle age; but none have ever been observed in the older and completely chemical formations. In the transition rocks, where they first occur, they are but rare, yet in the newer transition rocks they increase considerably in quantity. In the flœtz formations, they also continue increasing in quantity, to the newer formations.

In respect to the nature of these remains, Werner remarks, that those which occur in the earliest periods belong to the lowest and most imperfect class of animals, the zoophytes. In the newer and newer formations, we meet with quantities of shells and fish, and these are accompanied by a variety of marine plants. But these organic remains are completely different from any of the animals or vegetables of the present state of the earth. The organic creation during that period, appears to have had a totally different aspect from what it assumed in the succeeding. In the newer formations, we find the remains of known genera, and in the newest of all the remains of organic species, resembling those found in the present seas. Land plants appear later, and land animals still later. At first, they appear to have been but few, and very different from those of the present time. In the oldest of the transition rocks, which appear to have been formed while the earth was still covered with water, we find the remains only of marine plants and animals, but no traces of terrestrial organization. We first meet with such relics in the newer rocks of this class, which were formed after a portion of the land was uncovered, and capable of supporting terrestrial vegetation. From this period to the newest or alluvial, as we have already remarked, the quantity and variety of vegetable remains increase; and this is further confirmed by a correspondent increase of coal.

All the appearances we have now detailed are, in Werner's opinion, distinctly connected with the diminution of the water, and are to be considered as effects and proofs of its reality. It it evident that, during the period when the earth was still covered to a great height with water, neither plants nor animals had been created. When the water diminished in height, and the dry land began to appear, marine plants, and the lowest and most imperfect animals, were created. As the water diminished, it appears to have become gradually more fitted for the support of animals and vegetables, as we find them increasing in number, variety, and perfection, and approaching more to the nature of those in the present seas, the lower the level of the outgoings of the strata, or, what is the same thing, the lower the level of the water. The same gradual increase of organic beings appears to have taken place on the dry land.

The facts we have just detailed lead us to distinguish two grand epochas in the formation of rocks; the first anterior, and the second posterior, to the formation of organic beings. The rocks of the first division are named *primitive;* they contain no fossil organic remains, are situated below the others, and are wholly of chemical formation. The rocks posterior to the creation of organized beings are denominated *secondary.* Several of these resemble those of the primitive class in composition and structure; but differ from them in containing petrifactions. These Werner dénominated *transition,* and other geologists, *intermediate.* They partake partly of the primitive, partly of the secondary character, hence are named intermediate or transition. These transition rocks become intermixed with sandstones, and other rocks of the same description, and at length disappear; when a series of sandstone and limestone rocks, remarkable for their abundance of vegetable and animal remains, make their appearance, and form the *secondary, or flœtz rocks* of geologists. The newer, or upper rocks of the secondary class, are covered with an alternating series of limestone, gypsum, clay, sandstone, and sand, which abounds in fossil organic remains, and particularly of quadrupeds. The name *tertiary* has been given to these.

The great beds of gravel, sand, clay, marl, &c. which rest on the rocks of the preceding classes, form a class named *alluvial*. They contain abundance of organic remains, and even of animals, at the top of the zoological scale. Those rocks, which are undoubted productions of fire, are named *volcanic*, and form the fifth and last class of the series of mountain rocks. They are often posterior to secondary rocks, and sometimes even to substances of the alluvial class.

Werner, as indeed appears from what has been already stated, seems to consider all the mineral formations as formed by one and the same solution, which has gradually changed in height and in nature. But he saw that this explanation would not apply to every case: for example, if every rock, or bed, should occur at a height corresponding to its age, that is, at a higher level in old than in new rocks, how does it happen that porphyry, resembling those in primitive regions, rests upon secondary rocks, and attains a great elevation? A simple oscillatory movement, Werner remarks, would not explain this arrangement. It follows, therefore, according to Werner's principles, that a new solution must have invaded the district already abandoned by the old solution, and deposited the newer formations. Werner admitted these new inundations, and attributed to them some particular formations, such as the secondary trap rocks, and certain primitive porphyries.

Werner remarks, that when we view the various depositions from the earliest discoverable period to the newest, we find in them such differences, as show that the contents of the water of the globe must have changed by degrees, and that all its depositions form beautiful and connected series. The oldest rocks, which are pure chemical precipitates, are composed principally of siliceous, argillaceous, and magnesian earths. The rocks, as granite, gneiss, and mica-slate, contain metals that are of cotemporaneous formation with them, and that scarcely occur in newer periods; these are tin, molybdena, and tungsten.

This state of the water of the globe, however, alters gradually and remarkably, as we approach the newer periods, by the appearance of limestone in quantity, coal, and salt, and the disappearance of old and the appearance of new metals. Besides this general succession, (which will afterwards be particularly considered,) discoverable in the productions of different periods, we have instances of the repetition of certain products at considerable intervals, and in formations of different æras and kinds. In a series of this kind, all the members have general characters of agreement, and the individual members bear characters expressive, not only of the period of their formation, but also of the circumstances under which they were formed. Such a series, as we have already mentioned, is denominated a *Principal Formation Suite*, or *Series of Formations*. By contrasting the old and new members of such a series, the difference will be found so great, that we can with difficulty recognize them as members of the same formation suite: on the contrary, the immediately preceding or following members are so much alike, that it is equally difficult to distinguish the one from the other. This shews how much the prevailing circumstances that existed during the time of their formation, were alike in the members of the same age, and differed in those of a different date.

We shall now illustrate this subject by a short abstract of Werner's descriptions of several of these series of formations.

1. *Limestone Formation-Suite.*

The first member of this series is the white granular limestone, which occurs in primitive rocks, as gneiss, mica-slate, and clay slate. This limestone has large granular distinct concretions; but in the newest clay-slate, the concretions become more minute, and it even approaches to compact. The transition rocks contain the second member of this series, the variegated limestone, which has less translucidity than the preceding, but more than the following members of the series, and shews the first traces of petrifactions. The following, or flœtz rocks, contain the third member of the series, the grey flœtz-limestone, which is scarcely translucent on the edges, and is full of petrifactions. It has some resemblance to the limestone of the transition period, but only a very remote one to that of the primitive. How great is the difference between the granular translucent primitive limestone, and the dull earthy and nearly opaque flœtz limestone; and yet both are members of a series of chemical formations, which are still not the most distant. Chalk is a still newer formation, and the limestone and marls of the Paris formation connect the foregoing members, which have been deposited from the ocean, with the calc-tuff, the lowest link of this series of formations, (if we do not include the coral-rocks that are daily forming) which has been formed on the land. We have thus a complete series from the earliest to the latest period, in which we observe a gradual disappearance of the crystalline, and increase of the earthy aspect, corresponding with the relative age of the different members of the series, and the state of the solvent from which they were precipitated, and all serving as proofs of the immensely great, but gradual alteration of the state of the universal waters. If we even examine the individual members of this series, we find these gradations still more minute, but always very characteristic. Thus the limestone of the primitive period, (that which occurs in gneiss,) has the largest granular distinct concretions, and possesses the highest degree of translucidity and lustre, and has therefore the most highly crystalline structure of the whole series. Does not the highly crystalline structure correspond most intimately with a calm state of the solution? The next member of the series, which is still crystalline, but with smaller distinct concretions, occurs in mica-slate; and, still less crystalline, or with smaller distinct concretions, in the oldest clay-slate. In the newer clay-slate, on the contrary, the distinct concretions are so small, as only to be discoverable by their glimmering and translucidity. The white colour, which hitherto characterised the older limestone, is now intermixed with black, red, &c; and the newest members of this formation form the transition to the products of the next period. In the transition period, the limestone is compact, translucent, glimmering, and variegated or marbled.

The secondary or floetz-limestone contains several formations that resemble each other very much, and differ principally by the newer being more earthy than the older. To these succeed, as we have already mentioned, chalk and calc-tuff, which are in general still more earthy in their external appearance.

It is not enough, Werner continues, to detail the differences and agreements of this great series; we must also endeavour to discover how these have been produced. The whole series, as has been already observed, is completely chemical, yet the different members have distinct characters of difference. In the first and second periods, the productions are almost entirely chemical, but the crystallization becomes more imperfect, the newer the formation. Lastly, in the third period, the members of the series become mixed with small portions of mechanical matter, as is shown by the earthy aspect of many flœtz-limestones. We know the conditions necessary for the formation of a crystalline structure, and that rest and motion are the agents which assist or prevent its regular formation. Hence we may fairly infer, that the solution, or ocean, when it stood high over the earth, was calm and undisturbed. During succeeding periods, the solution appears to have become more and more agitated; yet at first it only prevented the perfection of the crystallization. As the water diminished in height, its motions increased; its destroying powers reached to the surface of the earth, and the crystalline shoots were destroyed, and thus the first mechanical productions were formed. The water still continuing to diminish, the dry land began to appear; of course the mechanical action of the water would be much increased, as also the formation of mechanical productions. How admirably does this agree with the appearances presented by this series of formations!

The connection and import of all these appearances will be more apparent, if we take a view of the characteristic position of the strata in the different members of this series of formations, and of their relations to the exterior of the earth. This will be considered particularly afterwards. At present we shall only mention the highly elevated level of the limestone in gneiss, contrasted with the low situation of chalk and calc-tuff.

2. *Slate Formation-Suite.*

This is a very extensive series of formations.* The limestone series is composed only of limestone, and a single earth, as its principal constituent part. In the series of clay-slate formations, on the contrary, different earths have united together, to form the rocks we shall now mention. Silica, alumina, and magnesia, but particularly the two latter, are the most characteristic earths belonging to this suite of formations. We shall begin the description with that member of the series which may be considered as a central point from which the others diverge, and which gives the name to the whole series. This is clay-slate. It is evident, that the oldest clay-slate must border on the newest Mica-slate; and the newest, on transition-slate. The oldest clay-slate has more lustre than the newer, and is even slightly micaceous, so that it resembles the fine slaty mica slate on which it rests. The newer clay-slate has a darker grey colour, less lustre, and contains finely disseminated scales of mica, which brings it nearer to the transition-slate. Mica-slate is an aggregate rock, composed of quartz and mica: but in the older, it becomes gradually intermixed with felspar, which, in the oldest varieties, increases, and shows itself more and more as an essential constituent part, until the mica-slate passes into gneiss. The texture of the newest gneiss which lies nearest to mica-slate is still thin slaty; but it becomes gradually coarser, more crystalline, thick slaty, and very nearly granular, when it passes into granite. In granite, the texture is completely granular, and this rock stands as the first and oldest member of the series.

The same clue will conduct us back to the transition-slate, which occurs in mountains of grey-wacke. Here distinct mechanical matter is mixed with the chemical. Grey-wacke is a complete sandstone; we have a gradation of its grains from those the size of a pebble, until, from their smallness, they are no longer distinguishable; and this constitutes a transition to grey-wacke-slate.

Sandstone, and sandstone-slate, are the next members of this series. The sandstone-slate resembles mica-slate so much, that it has been sometimes confounded with it. To the sandstone succeeds the coal formation, which contains friable sandstone and slate-clay. Lastly, the series is terminated by bituminous wood and earth-coal, accompanied with sand and clay; which latter correspond to the sandstone and slate-clay of the immediately preceding formations.

A material division of this beautiful series takes place with grey-wacke. From it, upwards, all the members are completely chemical. On the contrary, in the lower, the chemical is combined with mechanical, and only the lowest links of the series are completely mechanical productions.

3. *Trap Formation-Suite.*

In this series, all the formations have a great resemblance to each other; yet all of them bear very distinct marks of the period of their formation. The oldest or primitive greenstone is highly crystalline; the newer or transition is less crystalline; and in the newest or flœtz-trap, it approaches to earthy, as appears in basalt, and more particularly wacke, as the lowest links or farthest removed from the highly-crystalline primitive greenstone.

4. *Porphyry Formation-Suite.*

The first member of this series, or which is denominated the *Old Porphyry Formation*, occurs in great unbroken beds, in gneiss, and its basis is hornstone. The second member, or what is denominated the *Newer Porphyry Formation*, occurs in unconformable, over-lying, and broken stratification. Its basis is clay-stone, pitchstone, &c. The third and last member of this suite is probably the clay-stone, and porphyritic-stone which occurs in the coal-formation.

5. *Gypsum Formation-Suite.*

The oldest member of this formation occurs in mica-slate and clay-slate. The second member is that which accompanies salt, and with which salt-springs are connected. It lies over the old flœtz-limestone, and is covered by the second flœtz-sandstone. The third and last member is what is denominated the second gypsum formation of the flœtz period. It lies over the second sandstone formation, and under the second limestone of the flœtz period.

6. *Salt Formation-Suite.*

This series contains only two members. The first

* If we would judge of the propriety of the name given to this series, from its extreme members, it would appear very unappropriate. To judge rightly, we must consider it in the whole, or on the great scale.

and oldest occurs along with the oldest flœtz, gypsum, and the newer is that which is still forming at the bottom of the lakes.

7. *Coal Formation-Suite.*

This is a very interesting series. Inflammable matter occurs in considerable quantity only in the newer formations. The small portion that occurs in primitive mountains, is carbon, uncombined with bitumen. In the newer formations, bitumen makes its appearance; and in the newest formations, as in the flœtz-trap, we find immense accumulations of bituminous inflammable matter.

It was only after the deposition of these immense repositories of inflammable matter in the flœtz-trap, that volcanoes could take place: they are, therefore, to be considered as new occurrences in the history of nature, although they may extend far beyond historical record. The volcanic state appears to be foreign to the earth—a circumstance that points out its great antiquity.

8. *Serpentine Formation-Suite*

Contains but two members; the older, that which occurs in a conformable position with the primitive rocks; and the newer, that which overlies the primitive rocks.

The phenomena presented by all these formations, Werner remarks, coincides with the hypothesis of the gradual and universal diminution of the waters of the globe. We shall conclude what relates to that subject, by a general observation respecting the effects which would be produced on the surface of the earth by the diminution of the water; and then state the arrangement of the different formations, founded on the preceding observations respecting their order of succession.

It is evident, that as the water diminished, and the dry land appeared, the motion of the water would be altered, and its currents receive new directions, or be divided. These changes must have had a very powerful effect on the former surface of the dry land, and, by destroying a part of the earlier formations, would afford matter for newer formations.

FORMATIONS, *according to* WERNER.

PERIOD.	*Slate.*	*Limestone.*	*Trap.*	*Porphyry.*	*Gypsum.*	*Coal.*	*Serpentine.*
PRIMITIVE. *Stratification conformable*, with sinking levels of the out-goings of the newer and newer strata.	Granite.						
	Gneiss.	Limestone.	Hornblende-slate.	Oldest Porphyry.	- -	Slaty glance-coal.	Oldest Serpentine.
	Mica-slate.	Limestone.	Hornblende-rock.	Oldest Porphyry.	Oldest Gypsum.	Slaty glance-coal.	Oldest Serpentine.
	Clay-slate.	Limestone.	Primitive greenstone. Greenstone-slate.	Oldest Porphyry.	- -	Slaty glance-coal. Also Graphite.	Oldest Serpentine.
Stratification overlying.	Newest Granite.		-	Newer Porphyry, including Clay-Porphyry. Pitchstone-P. Obsidian-P. Pearlstone-P.–Also Sienite.			Newer Serpentine.
TRANSITION.	Grey-wacke. Grey-wacke-slate	Transition-Limestone.	Greenstone. Amygdaloid.		Transition-Gypsum.	Slaty glance-coal. Graphite.	
FLŒTZ. *Stratification conformable*, with sinking levels of the out-goings of the newer and newer strata.	1st Flœtz-Sandstone. 2d Flœtz-Sandstone. 3d Flœtz-Sandstone. Sandstone in the coal formation.	1st Flœtz-limestone. 2d Flœtz-limestone. Chalk. Limestone and Marl in the Coal formation.	Amygdaloid. Greenstone and Amygdaloid in the Coal-formation.	Porphyritic-Stone in the independent Coal-formation. It may be considered as the 3d Porphyry-formation.	1st Flœtz-gypsum. Rock-Salt Formation. 2d Flœtz-Gypsum.	In the independent Coal formation: Coarse-Coal. Foliated-Coal. Slate-Coal. Cannel-Coal. Pitch-Coal. Slaty glance-Coal Graphite.	
Stratification overlying.	Quartzy-sandstone, in the Newest Flœtz-trap formation.	Limestone in the Newest Flœtz-trap formation.	Greenstone. *Greystone.* *Porphyry-slate.* *Basalt.* *Wacke.* *Trap-Tuff.* Amygdaloid. Iron-clay.	Clay-stone? Compact-felspar? Pitchstone-Porphyry. Obsidian-Porphyry. Pearlstone-Porphyry.		In the Flœtz-trap formation: Pitch-Coal. Columnar-Coal. Conchoidal-glance-coal.—Also Bituminous Wood. Alum-earth. Common Brown Coal. Moor-Coal.	
ALLUVIAL.	Clay. Loam. Sand. Gravel. Rolled masses.	Calc-spar. Calc-tuff. Calc-sinter.				Earth Coal. Bituminous Wood. Also Moor Coal. Common Brown-coal.—And Alum-earth.	

CHAP. V.

We have already, in Chap. IV. established five classes of rocks, distinguished by the names *primitive*, *transition*, *secondary*, *alluvial*, and *volcanic*. We shall now describe these in the order just mentioned, beginning therefore with those of the primitive class.

Class I. Primitive Rocks.

Urgebirge.—*Werner.*
Terrains Primitifs.—*Daubuisson.*

Primitive rocks are those whose period of formation is considered as antecedent to that of the creation of organic beings. Hence we arrange in this class all those formations which have not been found to contain petrifactions or fossil organic remains. Should future observations, however, prove that these rocks do occasionally inclose animal or vegetable remains, still it would be well to consider them as a distinct class, and retain the name primitive, because, from their lying under the rocks of the other classes, they are to be considered as having been formed before them, and may, therefore, be said to be primitive, or first formed.

They are of chemical formation; and if mechanical deposites do occur associated with them, the quantity is inconsiderable. All those kinds which abound in mica are distinctly stratified, while the others that do not contain it are less distinctly stratified. The direction of the strata is frequently parallel with that of the mountain range in which they are contained.

All the different rocks of the class alternate with and pass into each other.

The constituent parts are quartz, felspar, mica, limestone, and hornblende, minerals indeed of which nearly the whole mass of the upper coat of the earth is composed. Of these minerals, the felspar, quartz, mica and hornblende occur together, and in various forms of aggregation, while the limestone forms beds of greater or less extent, which are but slightly intermixed or connected with the boundary strata.

The following are the rocks of this class:

1. Granite, with sienite, protogine, and topaz-rock.
2. Gneiss, with some varieties of white stone.
3. Mica-slate, with different varieties of talc-slate.
4. Clay-slate, with alum-slate, flinty slate, &c.
5. Granular limestone, and primitive gypsum.
6. Primitive trap.
7. Serpentine and euphotide.
8. Porphyry.
9. Quartz-rock.

I. *Granite.*

Granite. *Werner.*

Saxum, quartzo spato scintillante et mica, in diversa proportione mixtis compositum.—Granites. *Wallerius.*

Granite of the Germans, French, &c.—Moorstone of Cornwall. Whinstone and sandstone in some parts of Scotland.

1. The name *granite* is a corruption of the Latin word *geranites*, used by Pliny to designate a particular species of stone. The first modern writer who uses this word is Torneforte, the celebrated naturalist. It occurs in the *Account of his Voyage to the Levant*, published in 1699. Antiquarians appear to have named every granular stone capable of being used in architecture or statuary, granite, and it continued to be used in this vague sense by mineralogists until about fifty years ago, when true granite was distinguished as a particular mountain-rock.

2. It is a rock composed of grains or concretions of felspar, quartz, and mica, intimately joined together, but without any basis or ground. These parts vary in quantity, so that sometimes one, sometimes the other, and frequently two of them, predominate. Felspar is generally the predominating, as mica is the least considerable, ingredient of the rock. In some varieties, the quartz is wanting, in others the mica, and these have received particular names. Such distinctions, however, are useless, as these masses are to be considered as mere varieties, not distinct species.

The constituent parts differ also considerably in their magnitude: they alternate from large to small, and even very fine granular. In some varieties, the concretions of felspar and quartz are several inches in size, and the mica is in plates upwards of a foot square; while in others, the grains are so small that the granite appears nearly compact.

It differs also considerably as to colour; and this depends principally on the predominating ingredient, the felspar, the quartz and mica having usually a grey colour. The felspar is usually white, and most commonly greyish and yellowish white; also reddish or milk-white; sometimes also flesh-red. It is seldom grey, yellow, or green. The quartz is usually grey, seldom milk-white, and always translucent. The mica is usually grey, and sometimes nearly black.

The felspar in granite has usually a vitreous lustre, and perfect foliated fracture, yet in some varieties it passes into earthy, with the loss of its lustre and hardness; in short, it has passed into porcelain earth. This appearance is sometimes produced by the weathering of the felspar; sometimes it appears to be its original state. When veins containing pyrites traverse granite, the felspar and mica in their vicinity are converted into a kind of steatitical matter, by the action of the sulphuric acid formed during the decomposition of the pyrites. The mica sometimes also decomposes by exposure to the atmosphere; but the quartz is never altered. Granite, with earthy felspar, is found in Cornwall.

Sometimes the constituent parts of granite are regularly crystallized; principally, however, the felspar and quartz. The mica sometimes occurs in nests, unmixed with the other constituent parts, and these have been confounded with fragments. Sometimes the constituent parts are so arranged, that when the specimen is cut, its surface has a kind of resemblance to written characters: hence this variety has been denominated *graphic stone.* This particular variety is found at Portsoy, and in the island of Arran; also in the forest of Thuringia in Germany, in Corsica, in the mountain of Odontschelong, in the Uralian range, and also in France. Granite, with regular crystallized felspar, occurs in the island of Arran, in many places on the continent of Europe, and also in South America. At Mount St. Gothard, all the three constituent parts are found crystallized together. In the island of Arran and the Saxon Erzgebirge, there is a remarkable variety of granite, in which the felspar, quartz, and mica, have a diverging radiated structure.

Several other *varieties* of granite have been described by geognosts. Of these, the two most important are *protogine* and *sienite.* We shall now describe them.

Protogine.

In this variety, talc, either in the lamellar compact, or steatitic form, or as chlorite, takes the place of the mica. Mont Blanc, and the surrounding mountains, are formed of protogine. It is named protogine, (primævi,) because Jurine, the author of the name, considers it as of very old formation. Daubuisson proposes to name it simply talcose, or steatitic granite.

Sienite.

Sienite is a granite, in which the mica is generally replaced by hornblende; not always, as some varieties contain also mica. Werner says it is a granular aggregated rock, composed of felspar and hornblende, with occasional grains of quartz and scales of mica. It is named from Syene, in Upper Egypt, where the ancients quarried it in blocks of great magnitude.

Werner having remarked, that this rock was associated with the porphyries of Saxony, arranged it along with them, separated it from granite, and described it as a distinct species. On the Wernerian view, therefore, it is distinguished from granite by its hornblende and its situation. Our observations in Scotland oblige us to consider sienite as a variety of granite, as it occurs in the same beds with that rock, and exhibits every variety of geognostical position hitherto observed in granite.

Accidental mixed parts.—Besides felspar, quartz, and mica, the essential constituent parts of granite, and those minerals that take the place of the mica, viz. hornblende and chlorite, others sometimes occur in it. These, however, are to be viewed as accidental. Of these schorl is the most frequent, and the next are garnet and tinstone. The following also occasionally occur, either imbedded in the rock, or in veins that traverse it, viz. rock-crystal, adularia, chlorite, pinite, actynolite, common opal, topaz, corundum, fluor-spar, beryl, diallage, epidote, apatite, magnetical iron ore, and iron pyrites.

Granite, besides the granular, exhibit various other kinds of structure, such as *porphyritic*, *globular*, *tabular*, *columnar*, and *stratified*.

1. *Porphyritic.*—When large crystals of felspar occur imbedded in a basis of smaller granular granite, the porphyritic variety is formed. These imbedded crystals are sometimes upwards of a foot in magnitude, as is the case with some granites in Saxony, and in other countries.

2. *Globular.*—Some granites are disposed in roundish balls or concretions, which are from a foot to several fathoms in diameter. These balls are sometimes composed of curved lamellar concretions, which always include a harder central mass or nucleus. The spaces between the concretions are filled with granite of a softer nature, which decays readily, and thus leaves the harder central masses heaped on each other, or strewed about. Such heaps, or tumuli, have been erroneously described as rolled masses brought from a distance to their present situation, by the agency of currents that formerly swept the surface of the earth. Examples of this kind of structure occur in the island of Arran, Bohemia, the Hartz, the Fichtelgebirge, and in other countries.

3. *Tabular.*—Some granites, when they are traversed by parallel seams, appear divided into tables. These tables vary in extent from a few inches to several fathoms. They appear in some cases to be mere varieties of the stratified structure.

4. *Columnar.*—When the seams are arranged in directions parallel to several planes, the granite is divided into columnar masses, which resemble the columnar structure of trap and porphyry rocks. We many years ago, as mentioned in our account of the Hebrides, observed this columnar structure in the granite of Mull; and since that time Humboldt has described it as occurring in the granite of Caraccas, as it does in the granite rocks of Carlsbad.

5. *Stratified structure*, or *Stratification.*—Granite is sometimes disposed in great beds in gneiss and other rocks, and occasionally these beds appear divided into strata. In other instances, in granite mountains, we observe, besides the tabular, globular, and other structures, also the stratified; but this latter is, in general, less perfect than what is observed in gneiss, and other similar rocks.

6. *Beds in Granite.*—Granite does not afford so many different beds and veins as occur in gneiss, mica-slate, and other similar rocks. In Scotland, it sometimes contains beds of quartz and of felspar. In Switzerland, beds of quartz in granite have large drusy cavities, the walls of which are lined with magnificent crystals, and groups of rock-crystal. At Zinnwald, in Bohemia, the tin is worked in a quartz bed, situated in the middle of the granite. Beds of limestone are also met with in granite mountains, as in the Pyrenees; and some of them of great extent, having been traced by that excellent observer, Charpentier the younger, for four leagues, and with a thickness of ninety feet. We need not speak of the beds of gneiss, mica-slate, clay-slate, porphyry, trap, &c. upon which it often rests, and with which it frequently alternates.

7. *Metals in Granite.*—On a general view this rock contains fewer and less extensive metalliferous veins and beds than the slaty rocks of the primitive class. Tin, of all the metals, is that which is most peculiar to granite. Tin-stone occurs in the granite of Cornwall, Saxony, Limoges, and in these countries is generally associated with walfram.

Iron is frequent in granite. The mines of Traversella, in Piedmont, are situated in a granite which is subordinate to mica-slate. The mines of brown iron ore at Tauryniâ, and of Fillolo in the eastern Pyrennees, are in granite. Iron pyrites is frequently found disseminated through granite; and galena, or lead-glance, graphite, molybdena, bismuth, gold, silver, copper, zinc, manganese, cobalt, are among the metals sometimes met with in this rock.

8. *Formations of Granite.*—Granite occurs in masses, often many miles in extent, surrounded by gneiss, mica-slate, and clay-slate, and so connected with these rocks, that the whole may be considered as the result of one grand process of crystallization; that is, the granite is of cotemporaneous formation with the gneiss, as the gneiss is with the superimposed mica-slate; and the mica-slate, again, with the clay-slate which rests upon it. In other instances, the granite alternates in beds, often of enormous magnitude, with gneiss, mica-slate, clay-slate, and other primitive rocks, or it traverses these in the form of veins.

9. *Decomposition of Granite.*—Some granites resist, for ages, the destroying effects of the weather; while others are resolved into sand or clay in a comparatively short period. The obelisk which is at present in the

place of Saint Jean de Latran, at Rome, and which was quarried at Syena, under the reign of Zetus, King of Thebes, thirteen hundred years before the Christian era; and that which is in the place of Saint Pierre, also at Rome, and which a son of Sesostris consecrated to the sun, have resisted the effects of the weather for three thousand years.

On the other hand, there are granites, as those in some districts in Scotland, which are speedily disintegrated into gravel or sand. But between these two extremes, of extreme durability and rapid decay, there are numerous intermediate degrees. In the same mountain, or even in the same hillock, granites of different qualities will sometimes be met with. One portion will be excessively obdurate, and resist long the gnawing effects of the weather; another variety, immediately beside it, will be of a very decomposable nature; and while a third, associated with the two former, will possess an intermediate degree of durability. Granites vary in their mode of decomposition. Some assume the globular form; others that of rhomboidal or irregular masses. These are further disintegrated, and then the constituent parts fall asunder; when a kind of gravel, or sand, depending on the size of the grains, is formed. The felspar in this gravel is further altered, and easily changed into a clay, which is carried into hollows or plains, and forms beds of clay; the quartz grains, by attrition, are reduced in size, rounded in form, and give rise to beds of sand; and, when mixed with the matter of felspar, to sandy clays. The mica is further broken down, and becomes mixed with the clays and sands formed from the felspar and quartz.

The soil formed from decomposed granites, is in general comparatively unproductive.

10. *Shape of Granite Mountains.*—In those granite districts, in which the granite is of a loose texture, and easily acted on by the weather, the hills have a roundish form, and the lower granite tracts have a waved, or rather a mamillary outline.

But if very hard and indestructible granite rises through softer and more easily disintegrated, the harder portions appear in the form of peaks, needles, or in deeply dentated ridges, or cristæ, and thus give rise to the bristled and denticulated aspect so peculiar to many granite districts. The valleys, in granite countries, are in general very deep, narrow, and their sides often resemble immense perpendicular walls.

Granite rocks are frequently much traversed by rents or fissures. When these rents widen by the action of the weather, the mass separates into fragments of greater or lesser magnitude, which remain long piled on each other in a most fantastic manner, often appearing like vast artificial tumuli, or masses brought together by a flood. The upper parts of the granite mountains in Arran present very striking appearances of this kind, and I have observed the same in many places of the high granite ridges of the Riesengebirge. Travellers have described similar appearances in the mountains of Switzerland; those of Siberia; the Hartz; the Bohmerwald-gebirge, and the Carpathians.

11. *Geographical distribution of Granite.*—It is one of the most frequent and widely extended rocks. It occurs in almost every mountain group, and there it frequently juts out, forming its central and highest part, having the newer primitive rocks resting on it, or placed beside it. It forms mountains in this country, as in the island of Arran, and the central part of the Grampians. The same is the case in the Hartz, the Riesengebirge, the Bohmerwald-gebirge, the Fichtelgebirge, and the Alps, particularly those of Savoy; also in Bavaria, Bohemia, Franconia, Lusatia, Moravia, Upper Saxony, Thuringia, Austria, Stiria, and the Tirol. As granite is the basis on which the other primitive rocks sometimes rest, it may also appear in low mountainous situations, owing to the newer primitive rocks either not having been deposited, or having been washed away since deposition. Instances of this we have in the Island of Arran, near Carlsbad in Bohemia, and many other places.

The following list of localities shows the known extent of granite in the different quarters of the globe, without, however, any reference to its forming the centre and highest, or the lowest part of mountains or mountain-groups.

In Europe, it forms the range of Sewoga in Scandinavia; the rocks of Finland; occurs also in Cornwall in England, in the Hartz, the Forest of Thuringia, Erzgebirge in the Electorate of Saxony, the Fichtelgebirge, Lusatia, the Riesengebirge, the Bohmerwald-gebirge, the Schwarzwald (Black Forest,) the Alps of Switzerland, and Savoy; also in the Tyrol, Salzburg, Stiria, Archduchy of Austria, the Carpathian Mountains, Auvergne, Dauphiny, Elsass, and the Pyrenean Mountains.

In Asia, it forms the centre of Caucasus; occurs at Kolywan, and other places in Siberia; forms a very considerable portion of the Uralian, Altain, and Himalya chains of mountain-groups.

In Africa, it is said to form a principal constituent part of the mountains in Upper Egypt, the Atlas Mountains, and the country about the Cape of Good Hope.

America.—It occurs but in comparatively small quantity in the United States; and in Mexico, owing to the deep and high cover of porphyry, it is found only low down, as at Acapulco. In the Andes of South America, it is usually covered with gneiss, mica-slate, and trachyte, and in general is not observed higher than 6000 feet: but it abounds in the low mountains and regions of Venezuela, and of Parima, and descends even to the plains and to the level of the sea, as is the case on the sides of the Oroonoco, and the coasts of Peru.

In North America, it is said to occur in New York, Pennsylvania, and Virginia. In South America, it forms De los Mariches, near Caraccas, the whole Cordillera of Parima, Sierra Nevada de Merida, Torrito between South Carlos and Valencia, the country between Valencia and Portocabello, and Cape Horn, the southern extremity of America.

Uses.—It forms an excellent building and paving stone, and has been extensively employed in ornamental architecture.

Topaz-Rock.

This rock, which appears to be intimately connected with granite, has the following characters. Its constituent minerals are quartz, tourmaline, topaz, and lithomarge. It is composed of many small masses, which have the appearance of fragments, although they are true granular concretions. Each of these masses is composed of thin layers of quartz, tourmaline, and topaz; and these layers have different directions in the different masses or concretions. The quartz appears in granular concretions; the topaz is also granular; but is distinguished by its foliated aspect and hardness; lastly, the tourmaline is in small black needles. Frequently hollow spaces occur between these concretions, which are partly filled with crystals of quartz and topaz, but rarely contains tourmaline. The lithomarge occurs amongst these crystals, and has generally an ochre yellow, rarely green, and seldom white colour. It is worthy of remark, that the colour of the crystals of topaz, and also its intensity, depends on that of the lithomarge; as if this substance, or at least its colouring matter, was the same as that of the topaz.

Topaz rock is very distinctly stratified, and the strata are of considerable thickness. It rests upon granite, and is covered by clay-slate.

It has hitherto been found only near to Auerbach, in Voightland, in Saxony, where it forms a rock named *Schneckenstein*, which was formerly of considerable extent, but has been much diminished by the operations of the miners in procuring topazes.

The inconsiderable extent of this mass prevents our viewing it as a distinct species of mountain rock.

II. *Gneiss.*

Gneiss.—*Werner.*
Gneiss and Granite Veinè —*Saussure.*
Gneiss.—*Kirwan.*—*Jameson.*

1. *Name.*—The name *Gneiss* is of Saxon origin, and was applied by miners in the vicinity of Freyberg, to the decomposed stone that forms the walls of their metalliferous veins. Henkel describes gneiss as an indurated stone, mixed with a steatitical and clayey matter; but Werner ascertained that it was a compound of felspar, quartz, and mica.

2. *Constituent Parts.*—This rock, like granite, is a compound of felspar, quartz, and mica; but it contains more mica than granite. It is granular in the small, and slaty in the large; hence it is said to be granular-slaty. The granular felspar and quartz form plates, which are separated from each other by the mica.

Felspar, although the predominant mineral, is still in less quantity than in granite. The felspar is usually greyish, yellowish, and reddish-white; and sometimes so much altered that it appears earthy. The mica is most commonly grey, which passes through various shades into blackish-grey. The quartz is almost always greyish-white, and generally in smaller grains than the felspar.

3. *Imbedded Minerals.*—Besides felspar, quartz, and mica, it sometimes contains schorl; more rarely garnet, and also hornblende. The schorl occurs more rarely, and in less quantity, than in granite: but the garnet is more frequent and abundant than in granite.

4. *Kinds of gneiss.*—There are three principal kinds of gneiss, of which we shall now give short descriptions.

(1.) In this kind the mica occurs in small quantity: the scales of mica, although separated from each other, are arranged in parallel ranges, and the rock breaks in a direction conformable with these. It is the parallelism of the ranges of mica which distinguishes this kind of gneiss from granite, because its slaty structure is very indistinct, and the quantity of felspar is nearly the same as in granite. The quartz and the mica form each separate layers; those of the felspar are thicker, and such varieties, when broken across, have a ribbon-like aspect. Sometimes the quartz, in place of being disposed in layers or plates in the felspar, is in small parallel rods or bars; and when the rock is cut perpendicular to their direction, it appears not unlike petrified wood.

(2.) This, which is named *common gneiss*, consists of small layers, or lenticular plates, composed of grains of felspar and quartz, placed over each other, and separated by layers formed of scales of mica. It is sometimes glandular, or contains balls of quartz, or of compounds of quartz and felspar, or of mica. This variety has been confounded with conglomerate. The island of Fetlar, one of the Shetlands, affords an example of this variety.

(3.) This, the third variety, is very slaty, and very micaceous. The scales of mica, from their smallness, appear indistinct, and form continuous plates. The felspar and quartz are in very small grains, and are sometimes so enveloped in the mica, that it is difficult to distinguish them. It is also sometimes glandular, and in some instances almost an aggregation of balls of mica.

The gneiss which passes into granite belongs to the first variety, as that which passes into mica slate does to the third.

5. *Stratification.*—It is distinctly stratified, and the strata are parallel with the slaty structure. But when the beds rest upon granite, they sometimes follow all the sinuosities of the irregular surface of that rock, and form the mantle-shaped stratification; in other cases the stratification is saddle-shaped, or it does not appear affected by the granite, the strata passing without change of direction from one mass of granite to the other.

6. *Decomposition.*—This rock, like granite, decays on exposure to the atmosphere, but the decomposition is in general more rapid. The felspar is at first changed into kaolin, and, owing to the greater abundance of mica, the disintegration of the mass is more rapidly effected. Hence it is that this rock does not occur so often in great isolated blocks as granite; and hence also it is that mountains of gneiss are often less sharp in their outline than those of granite, that their summits are generally roundish, and that they rarely shoot into needles, or are formed into denticulated ridges.

Sometimes the decomposition, in penetrating the gneiss, loosens the adherence of the parts; the folia are then easily separated by the finger, and the mass appears as if rotten.

7. *Foreign beds.*—These beds are more considerable and more numerous in gneiss than in granite. The following may be enumerated.

Limestone.—It is generally highly crystallized. Occurs in Aberdeenshire, Perthshire, and other parts of Scotland; and on the continent of Europe, in the Pyrenees, in Dauphiny, &c.

Trap.—This rock, in the form of hornblende rock, hornblende-slate, and greenstone, occurs in beds, and in imbedded masses, and is often very much intermixed with the gneiss. When the gneiss abounds in hornblende, it is named *hornblendic gneiss.*

Porphyry.—Beds, imbedded masses, and veins of porphyry, sometimes of great magnitude and extent, are not unfrequent in some gneiss districts. Perthshire, Aberdeenshire, and Inverness-shire, afford fine examples of porphyry in beds, imbedded masses, and veins.

Compact and granular felspar.—The white stone. Weisstein of *Werner.*—This rock sometimes occurs in layers, which are not more than a few inches thick; in other instances in beds, so thick as to form whole mountains. The felspar is white, and is very fine granular, like dolomite: it contains numerous grains of red garnet, even grains of quartz, and sometimes scales of white mica. In short, it is to be considered as a granular felspar, generally containing scales of mica, with some grains of quartz, and of other minerals. It forms beds and whole hills in Saxony, Moravia, and Sweden.

Quartz Rock.—This rock occurs in great beds, and sometimes also in veins in gneiss districts.

Besides the beds above described, gneiss contains occasionally granite, mica-slate, and clay-slate.

Glance Coal.—The slaty kind sometimes occurs in beds in gneiss.

8. *Metalliferous Minerals.*—Gneiss is one of the most metalliferous of the primitive rocks. The metals occur in veins, beds, and imbedded masses, but in greatest variety in veins. There are few metals that do not occur in it. Most of the Saxon, Bohemian, and Saltzburgian mines, are situated in this rock. The oldest gneiss in the Saxon Ergebirge, that with reddish-coloured felspar, is the least productive in ores; but the newer, with white-coloured felspar, is the most productive; and the veins, though small, are numerous. The oldest venigenous formation appears to be that which contains tinstone. The tin-ore is accompanied with wolfram, molybdena, arsenic-pyrites, fluor-spar, chlorite, topaz, and opal. The second venigenous formation appears to be lead-glance. The third formation consists principally of copper, and the ores are grey copper-ore, copper-glance, copper-pyrites, and variegated copper-ore. The fourth formation, which is very extensive, contains ores of cobalt. The newest formation is that which contains ores of silver. Veins, containing antimony and red ironstone, occur in gneiss, and these are supposed to be newer than any of the preceding. Veins of quartz with gold also occur in gneiss.

The metalliferous beds that occur in this rock contain magnetic iron-ore, argentiferous lead-glance, blende, copper and iron pyrites.

The lead-mines of Strontian, in Argyleshire, are situated in gneiss.

Geographical distribution.—It is a very widely distributed rock. It is found in almost every country where granite occurs; and is often interposed between granite and mica-slate, or is contained in mica-slate, or even in clay-slate. It is an abundant rock in Scotland, forming extensive tracts in the middle and northern divisions, and also in the islands. It is the principal rock in Sweden and Norway. It occupies almost the whole of the Saxon metalliferous mountains: it abounds in Bohemia and Silesia; it is not uncommon in the Black Forest, the Upper Palatinate, in Carinthia, in the Southern Alps, the Pyrenees, and the Vosges. It occurs also in Greece; and, in the vicinity of Athens, the old mine-works of the ancients are situated in it. It is an abundant rock in the United States of America, and in South America: Humboldt met with it in the high chain of the Andes of Quito, in the mountains of Parima, and Venezuela.

III. *Mica-Slate.*

Glimmer-Schiefer.—*Werner.*
Micaceous Schistus.—*Kirwan.*
Mica-Slate.—*Jameson.*
Schiste micacé.—*Brochant.*
Rocke Feuilletée, et quartz, ou Schiste micacé.—*Daubuisson.*—*Saussure.*

1. *Constituent Parts.*—This rock is composed of mica and quartz, and, like gneiss, has a slaty structure. The mica is generally the predominating ingredient: its colour is grey, sometimes inclining to green, sometimes to yellow, and more rarely to brown. It is often disposed in continuous plates, not in distinct scales, as in gneiss. The quartz is grey, with its usual vitreous lustre, and is disposed in thin lenticular masses, interposed between the plates of mica. Sometimes these masses increase in magnitude, and become globular, and then the rock acquires a conglomerated structure. Although the mica forms the principal and predominating ingredient in mica slate, yet it sometimes happens that the quartz is the most abundant, and thus a transition is formed into quartz rock.

2. *Varieties.*—We can distinguish different kinds of mica-slate. These are *Common*, *Undulated*, *Talcky*, *and Fine Slaty.* The *common* is straight, and rather thick slaty, and contains garnets, and sometimes felspar. The *undulated* has a waved structure, and contains neither garnets nor felspar. The *talcky* is straight slaty; contains thick layers of quartz, and the mica has a green colour, and inclines to talc. The *fine slaty* borders on clay-slate, (the next rock in the order of succession,) has a light yellowish grey colour, and contains extremely little quartz; it passes imperceptibly into clay-slate. Of these, the oldest is the Common, and the newest the Fine-slaty.

3. *Imbedded Minerals.*—It frequently contains imbedded minerals of different kinds. The principal of these are the following:

(1.) *Garnet*, either in grains or in crystals, and is so frequent and abundant, that it may almost be considered as a characteristic and principal ingredient of the rock. It abounds in mica-slate districts in Scotland, and on the continent of Europe.

(2.) *Tourmaline and Schorl.*—These are met with in the mica-slate of Scotland, and in other countries.

(3.) *Grenatite.*—This mineral occurs in the mica-slate of the county of Wicklow in Ireland, and in districts of the same description on the continent of Europe.

(4.) *Chiastolite.*—This curious mineral is found in mica-slate in the Pyrenees.

(5.) *Kyanite.*—Is found in the mica-slate of the Shetland islands, and also in a similar rock in Banffshire.

(6.) *Emerald.*—The beautiful emerald, found in Egypt, occurs in mica-slate.

Besides the minerals already enumerated, many others, as vesuvian, rutile, graphite, &c. occur in mica-slate.

4. *Stratification* and *Position.*—It is very distinctly stratified. The strata are sometimes variously convoluted, and the same character occurs in the substance of the strata. It often rests on gneiss, and is covered by clay-slate. It passes, on the one hand, into gneiss, and the transition is made by the common kind; and on the other into clay-slate, and the transition is made by the fine-slaty kind. The out-goings of the strata are frequently lower than those of the gneiss, on which they rest, and higher than those of the clay-slate that cover them. It sometimes also occurs in beds in gneiss, and clay-slate, and even in granite.

5. *Foreign Beds.*—It contains more foreign beds than gneiss. The following have been observed: Granular-limestone, dolomite, hornblende-slate, and hornblende-rock, actynolite, garnet, talc, serpentine, chlorite, quartz-rock, magnetic iron-stone, magnetic pyrites, copper-

pyrites, iron-pyrites, arsenic-pyrites, blende, lead-glance, and red ironstone.

6. *Form of Mountains.*—The acclivities of the mountains are gentle, but the cliffs it forms are not so considerable as those in gneiss mountains. When mural precipices occur, they are seldom of great height. The summits of the hills are round backed.

7. *Metalliferous Minerals.*—It is one of the most metalliferous of the mountain-rocks. The ores it contains occur frequently in beds, but more rarely in veins, which is directly the reverse of gneiss, where ores occur more frequently in veins than in beds. The ores that occur in beds are the following: magnetic ironstone, iron-pyrites, copper-pyrites, arsenic-pyrites, red-iron ore, lead-glance, blende, gold, and glance-cobalt; and these ores are accompanied with actynolite, garnet, and asbestus.

The veins that occur in mica-slate contain in general the same ores as those in gneiss.

The gold mines at the foot of Monte Rose are principally in mica-slate; and this is also the case with some of those in the country of Salzburg. The silver mines of Johan-Georgenstadt and Braunsdof in Saxony; those of Sweden and Norway are in these rocks. Many of the mines in Silesia and Bohemia are in mica-slate.

The most important mines in Sweden, as those of Dalecarlia and Fahlun; those of Roraas in Norway; many in Hungary and Salzburg, Saxony and Bohemia, are situated in this rock.

8. It occurs in great abundance in Scotland; as in the valley between Dunkeld and Blair-in-Athol; the mountain of Schihallion, and the neighbouring country; island of Arran; islands of Jura and Isla, &c. It is also very widely distributed in the continent of Europe; as in Saxony, Bohemia, Silesia, France, Spain, the Bannat, Transylvania, Switzerland, Salzburg. It also occurs in the United States, in South America, and in the continents of Africa and Asia.

IV. *Clay-Slate.*

Thonschiefer.—*Werner.*
Primitive Argillaceous Schistus, *Kirwan.*
Clay-Slate.—*Jameson.*
Schiste argileux, *Brochant.*
Phyllade.—*Daubuisson.*

1. *Characters.*—*Clay-Slate* is a simple mountain-rock, having a slaty structure, with a fine grained, and dull cross fracture; it is opaque and soft, with a grey streak, whatever may be its colour. Its most frequent colours are grey, or bluish black; very often greenish-grey; more rarely yellowish-grey and brownish-red. Oxide of iron is the general colouring ingredient; but in the black varieties it is carbon, which gives the tint of colour. The greater number of varieties split easily into slates, which are either plain or variously convoluted. Their surface is sometimes smooth, in other instances it is traversed by deep striæ; and it is sometimes dull, sometimes shining with a silky or pearly lustre. It is intimately connected with mica-slate, and there is a distinct transition from it into that rock, by the gradual disappearance of the quartz, thus shewing that it is entirely composed of mica in very minute and closely aggregated scales.

2. *Varieties.*—There are four varieties of clay-slate. The *first kind* has a yellowish-grey colour, and a shining lustre: it is the oldest kind, to use the language of Werner, and is that which reposes immediately on mica-slate; it is in short the link that connects clay-slate with mica-slate. The *second kind* is dark-grey; sometimes even bluish-grey and greyish-black, forming what is denominated *roof-slate*, from the circumstance of its splitting into thin and large tables. We must be careful, however, not to consider all roof-slate as of primitive formation. To this follows, in the order of succession, the *third kind*, which has a greenish-grey colour. The *fourth* and last, which is the newest kind of clay-slate, is bluish-grey, and reddish: it contains a very few intermixed scales of mica; possesses but little lustre; and is the link that connects the primitive clay-slate with the transition clay-slate.

3. *Stratification.*—It is distinctly stratified, and its slaty structure is generally parallel to the seams of the strata; in some cases, however, a double cleavage is observable; and Count de Bournon observes, that many clay-slates break under angles of 60° and 120°, which he supposes may be owing to the presence of mica. The strata are in general much inclined, and are often variously convoluted and waved, and sometimes they appear to be composed of different concretions.

4. *Imbedded minerals.*—Independent of the grains of quartz and scales of mica irregularly distributed through it, we find it containing large imbedded masses of quartz, of hornblende, and crystals of chiastolite.

5. *Subordinate Beds.*—It contains a greater variety and number of foreign beds than gneiss or mica-slate; and of these some are nearly peculiar to it, and characterise the whole formation. We shall first mention those which are common to gneiss and mica-slate, as well as clay-slate, and then those that are peculiar to clay-slate.

(1.) Rocks that occur in gneiss, mica-slate, and clay-slate. 1. *Limestone.* 2. *Hornblende-rock.* 3. *Primitive Greenstone.* 4. *Hornblende-slate.* 5. *Porphyry.* 6. *Quartz.* 7. *Actynolite.*

(2.) *Rocks peculiar to the clay slate formation, or which occur very frequently in it.* 1. *Whet-slate.* It occurs in beds, in Saxony, Bavaria, Silesia, Stiria, and other countries. 2. *Roof-slate.* This is but a variety of clay-slate, distinguished by its bluish or ash-grey colour; its straight slaty fracture; its splitting into large tables, and its being nearly pure and unmixed. It seldom or never forms whole mountains, but occurs usually in single thick beds with other kinds of clay-slate. 3. *Chlorite-slate.* This usually follows the preceding. It forms whole beds, and includes garnets, crystallized magnetic iron-stone, iron-pyrites, common schorl, tourmaline, and quartz. 4. *Talc-slate.* This is usually the next in the order of succession. 5. *Alum-slate.* It occurs in considerable beds in clay-slate; and the two sub-species, the common and shining, alternate with each other. It contains a portion of carbon, and also iron-pyrites. 6. *Drawing-slate.* It occurs usually in the vicinity of alum-slate, and is very nearly allied to it. It contains more carbon than alum-slate, but less iron-pyrites. 7. *Potstone* occurs in considerable beds. 8. *Flinty-slate* occurs in considerable beds in this great formation. 9. *Lydian-stone* occurs in beds and imbedded masses.

6. *Formations.*—This rock occurs along with mica-slate, and sometimes in beds in gneiss, and even in granite.

7. *Form of mountains.*—It sometimes forms whole

mountains, and even chains of mountains. Its mountains have usually a gentle acclivity; and its cliffs are not so steep and rough as those of mica-slate or gneiss. It is more favourable to vegetation than any of the rocks we have hitherto described; and it is observed that the quantity of vegetation increases from granite to clay-slate; and this appears to depend, not so much on the lower level of the outgoings of its strata, as on the nature of the rock itself.

We can thus observe a gradual change in the shape of mountains, also of their cliffs and valleys, from granite to clay-slate; and these differences are so striking and characteristic, that a long experienced eye can, at a glance from the summit of a mountain, point out with considerable certainty the different formations of which a country is composed. Landscape-painters, by confounding together all these differences, or by combining them irregularly, fail not only in accuracy, but in giving their work that appearance which shows, at first glance, that it is not only a copy of nature, but a copy by one who has formed a distinct conception of the most general and particular features of the inequalities observable on the surface of the earth. Some affect to maintain, that the grand features of mountains and plains are different in different zones. Thus, that in the torrid zone, for example, the shape, cliffs, and other appearances in mountains, are different from those in the temperate zone. This, however, is a mistake; for the same formation in all countries presents similar external characters; and as the great formations are universal, no such differences can exist. It is true, that the blue colour of the heaven, its degree of illumination, the appearance of distant mountain-vapour, the shape of animals, the luxuriance of vegetables, combined with the features of mountains, will form a particular character for each climate; but still the aspect of the rocks of the same formation, in whatever country they occur, will be the same. Thus cliffs of granite and mica-slate have the same appearance in India and Siberia as in Scotland; and the valleys of the Urals do not differ in shape and other features from those formed by similar rocks in this neighbourhood.

7. *Metalliferous Minerals.*—Clay-slate is rich in metals. It contains many of the venigenous formations that occur in the preceding primitive rocks, as tin, lead, cobalt, and silver. Very considerable metalliferous beds also frequently occur, and these contain copper pyrites, red copper-ore, copper-green, blue copper, malachite, iron-pyrites, magnetic pyrites, glance-cobalt, grey cobalt-ore, arsenic-pyrites, blende and lead-glance. Gold also occurs in this formation, and it is said also cinnabar.

8. *Geographical distribution.*—It is a very widely extended rock. In this country, it skirts the Highlands from Lochlomond by Callender, Comrie, and Dunkeld; in the whole of that extensive district, resting on and gradually passing into mica-slate; the same appearances are to be observed in many other quarters in Scotland. On the continent of Europe, it has been traced through a great extent of country; thus it occurs in Saxony, Bohemia, Silesia, Franconia, Bavaria; the Alps of Switzerland, Austria, Hungary, and many other parts in Europe. It occurs also in considerable quantity in North America, as Pennsylvania; also in immense quantity in South America; thus it is said, that nearly the whole country between Potosi and Lima is composed of it. In some of the districts above enumerated, transition clay-slate has been confounded with the primitive kind.

V. *Primitive Limestone.*

Ur. Kalkstein.—*Werner.*
Primitive Limestone.—*Kirwan.*
Primitive Limestone.—*Jameson.*
Calcaire Primitif.—*Brochant.*

Characters.—This is a simple mountain rock. Its most common colours are snow, yellowish, greyish, greenish, and reddish white; it is sometimes also grey, and the newer varieties incline to yellow. Its structure is always granular. Those varieties which are associated with granite and gneiss are generally more crystalline than those contained in mica-slate and clay-slate; and, in general, primitive limestone is more crystalline than secondary. Werner remarks, that in the oldest members of the series, that is, in those contained in granite, the colour, of the limestone is pure white, translucent, and coarse granular; in the newer members, the colour is less pure, the translucency less considerable, and the granular distinct concretions smaller; and in the newest, the concretions are so small as only to be discoverable by their glimmering lustre.

2. *Imbedded Minerals.*—It frequently contains accidental ingredients, and these occur more frequently in the older than in the newer members of the series. We shall mention some of these: 1. *Quartz.* It occurs in massive pieces of greater or less magnitude, and sometimes also in crystals. 2. *Mica.* It sometimes occurs in such quantity as to give the stone a slaty fracture. These two minerals, namely, quartz and mica, are the most common accidental minerals that occur in primitive limestone. Those of less frequent occurrence are the following: common hornblende, actynolite, asbest, serpentine, augite, talc, steatite, felspar, epidote, tremolite, garnet, calc-spar, slate-spar, and pyrites.

3. *Stratification.*—It occurs more or less distinctly stratified. It was once the opinion, that granular aggregated stones, as primitive limestone, granite, sienite, and greenstone, were never stratified. This, however, is a mistake. Primitive limestone also occurs in beds of greater or less magnitude; sometimes these beds are short and thick, and are then said to form lying masses (liegende Stöcke;) or the beds are so thick as to form whole mountains; but this latter is a rare occurrence.

4. *Formations.*—There are several formations of primitive limestone. Thus it forms one formation in granite, another in gneiss, a third in mica-slate, and a fourth in clay-slate. It is more abundant in mica-slate than in granite or gneiss, or even in clay-slate.

5. *Metalliferous Minerals.*—It frequently contains ores of different kinds, and these occur often in beds, but seldomer in veins. The metalliferous beds contain ores of different kinds, as lead-glance, blende, magnetic ironstone, magnetic pyrites, auriferous arsenic pyrites, and native gold. The veins are very inconsiderable, and by some mineralogists are said to contain principally manganese.

6. Several beautiful varieties occur in this country, as in the islands Tiree, Icolmkill, and Skye; also in Perthshire, as in Glen Tilt, in Assynt, in the county of Sutherland, and many other places. The promontory of Athos, in the Archipelago, is said to be composed of primitive limestone; also the Island of Paros, and part of the Appenines, as about Carrara and Massa, many parts of the

Alps of Switzerland, the Pyrenees, Carrapatos in Portugal, Bohemia, Saxony, Silesia, and many other parts of the continent of Europe.

8. *Uses.*—The finest statuary marbles are found in primitive mountains, and also many of the varieties used in ornamental architecture.

Primitive Gypsum.—Hitherto this rock has not been observed to form masses or beds of considerable extent in primitive mountains. Nearly the only authentic example recorded of primitive gypsum, is that given by Daubuisson, who informs us he discovered a bed of it in mica-slate, in the valley of Aoste, and near the village of Cogne.

VI. *Primitive Trap.*

Ur-Trap.—*Werner.*
Primitive-Trap.—*Jameson.*
Granitelles, Trap, Corneennes.—*Saussure.*
Trapps Primitifs.—*Brochant.*
Amphibolite.—*Daubuisson.*

1. *Name.*—The name trap is derived from the Swedish word *trappa*, signifying a stair. It would appear that this name was first used by Rinman, in a memoir on ferruginous stones, published in 1754. The Swedes applied this name to rocks, which, on exposure to the air, assumed shapes resembling the steps of a stair. It was, however, soon extended to a considerable variety of rocks of very different formations; hence Werner found it necessary to restrict its signification. He understands by trap, rocks principally characterized by the presence of hornblende and black iron-clay. Hence all rocks occurring in the primitive class, having hornblende as a characteristic or predominating ingredient, belong to the Primitive Trap Formation.

2. *Varieties.*—Hornblende occurs in trap rocks, either alone or mixed with other minerals, and having different structures; and this arrangement affords a good basis for their subdivision. In the oldest trap, no iron-clay occurs; it first makes its appearance in the transition period, and increases in the newer periods.

Primitive Trap, in particular, is almost always distinguished by a great predominance of hornblende, so that some of the kinds are wholly or almost entirely composed of hornblende. This character affords the first sub-division of primitive trap.

There are three principal species of primitive trap, and these again have their subordinate kinds.

The following table exhibits the rocks of this series.

1. Common hornblende rock.
   - *a.* Granular hornblende rock.
   - *b.* Hornblende-Slate.
2. Hornblende mixed with felspar.
   - *a.* Greenstone. *Diabase.—Brongniart.*
     - α. Common Greenstone.
     - β. Porphyritic Greenstone.
     - γ Greenstone Porphyry. } *Aphanite.—Hauy.*
     - δ. Green Porphyry. }
   - *b.* Greenstone Slate. *Diabase schisteuse.*
3. Hornblende mixed with mica.

The three principal species are, 1. *Common Hornblende-rock*; 2. *Hornblende mixed with felspar*; and, 3. *Hornblende mixed with mica.*

1. *Common Hornblende-rock* is almost entirely composed of Hornblende. It contains two subordinate kinds; the first is denominated *Granular Hornblende-rock*; the second, which differs from the first only in having a slaty structure, is denominated *Hornblende-slate.* It passes sometimes into gneiss, and sometimes into chlorite-slate, and often into hornblende-rock. These two rocks occur in beds, in gneiss, mica-slate, and clay-slate, but the beds are thicker and more numerous in the clay-slate than in mica-slate or gneiss.

It occurs in the islands of Arran, Coll, and Tiree; also in the district extending from Loch Lomond to Dunkeld, and many other places of the Highlands of Scotland. It abounds also in Bohemia, Saxony, the Tyrol, Siberia, and many other countries.

2. *Hornblende mixed with Felspar.*—This species contains two subordinate kinds; the first is *Greenstone*, the second *Greenstone slate.*

(1.) *The Greenstone* comprehends the following varieties: *Common Greenstone*, *Porphyritic Greenstone*, *Greenstone-Porphyry*, and *Green Porphyry.*

a. *Common Greenstone* is a granular aggregate of hornblende and felspar. b. *Porphyritic Greenstone* is the preceding kind, including large crystals of felspar, and consequently having a porphyritic structure. c. *Greenstone Porphyry.* In this variety the granular basis, which is with difficulty distinguishable, includes crystals of felspar. It is the Black Porphyry of the ancients. d. *Green Porphyry.* In this variety the granular nature of the basis is no longer visible to the naked eye; it appears uniform and simple; has a blackish green or pistachio green colour, and includes crystals of compact felspar. It is the *Porfire verte*, or antique green porphyry of antiquaries. The Variolite probably belongs to the green porphyry.

Greenstone appears sometimes stratified. Its different varieties first appear in gneiss, then in mica-slate, and lastly in clay-slate. In mica-slate, but more particularly in gneiss, the beds are few and inconsiderable; whereas in clay-slate they are numerous and of great magnitude. It probably, in some instances, occurs in an unconformable and overlying position, and hence may be sometimes considerably newer than clay-slate.

It occurs abundantly in this country. Thus the clay-slate and mica-slate that form so great a portion of the country extending from Loch Lomond, by Callender, Comrie and Dunkeld, contain numerous beds of greenstone; and there, as is the case in all other countries, the clay-slate contains more numerous and larger beds than the mica-slate. It is also very abundant on the continent of Europe, as Norway, Saxony, Bohemia, Silesia, Thuringia, Hungary, the Alps of Switzerland, and Savoy.

(2.) *Greenstone-slate* is composed of hornblende and compact felspar, and has a distinct slaty structure. The felspar in general is rather more abundant than the hornblende. It sometimes contains scales of mica.

It occurs only in clay slate, and according to Werner is the newest of the primitive traps. It occurs in great beds, and even mountain-masses; so that in some countries, as Sweden, it is said to form ranges of hills. It is very metalliferous. The celebrated mining district of Gersdorf, in Saxony, is situated in this rock. The mining district of Rudolstadt in Silesia, and of Adelfors in Sweden, are also in greenstone-slate.

3. *Hornblende mixed with Mica.*—This is an intimate mixture of hornblende and felspar, that includes scales of mica. It occurs, in beds, in gneiss and mica slate.

VII. *Serpentine.*

Serpentine.—*Werner.*
Serpentine.—*Kirwan.*

Serpentine.—*Jameson.*
Serpentine.—*Brochant.*

1. *Minerals imbedded in it.*—It is to the eye a green coloured simple mountain rock, of which a description will be given in our account of Simple Minerals. It frequently contains accidental minerals, or is indeterminately mixed with another mineral. Of the latter only one instance is known. It is the mixture of limestone and serpentine, forming what is denominated *verde antico.* The accidental mixed minerals are common talc, indurated lithomarge, steatite, common asbestus, amianthus, mica, schiller-stone, native magnesia, magnesite, meerschaum, actynolite, rock-cork, rock-wood, diallage, pyrope, opal, chrysoprase, hornstone, amethyst, quartz, and hornblende crystals.

2. *Subordinate beds.*—The only beds it contains are limestone and euphotide.

3. *Stratification.*—It is scarcely ever stratified, and when traces of stratification do appear, they are very indistinct.

4. *Metalliferous minerals.*—It always contains magnetic ironstone, either in imbedded grains and masses, or in small veins, and these are sometimes so considerable as to be worthy of being worked as mines. There are mines of this description in the Alps. The chromate of iron, so much valued in the arts, occurs disseminated, also in imbedded masses and in veins in this mountain-rock, in the Shetland Islands, and at Portsoy. On the continent of Europe, in Provence, and in Stiria, and in the New World in the United States of America. With exception of iron, this rock contains but few metalliferous minerals; nevertheless, near to Joachimsthal, in Bohemia, it contains so much galena, that a mine is established in it; and in Cornwall, and in the Shetland Islands, it contains native copper.

5. *Formation.*—It occurs in beds and mountain masses in gneiss, mica-slate, and clay-slate.

6. *Decomposition.*—On exposure to the weather, its surface becomes earthy, and the colour changes from green to ochre-yellow, owing to the change of the protoxide of iron into hydrate of iron. It resists the destroying effects of the weather more obstinately than the gneiss, mica-slate, or clay-slate, with which it is associated, and hence peaks and other projecting forms of serpentine, are observed on the Alps rising through the softer and less durable surrounding gneiss and other rocks.

Like all other magnesian rocks, it is inimical to vegetation. The mountains of which it is composed are bare and bleak; and this nakedness, joined to the sombre colour, gives a dreary and monotonous aspect to most serpentine districts.

7. *Geographical distribution.*—It occurs in great beds in the Shetland islands, along with gneiss, mica-slate, chlorite-slate, and quartz-rock; in beds at Portsoy in Banffshire, along with quartz-rock, trap-rock, mica-slate, and limestone; near Cortachie in Angushire; in Invernesshire, and other parts of Scotland; and abundantly in Cornwall in England.

It is very abundant in the Alps, in beds often of enormous thickness. It also occurs in the Pyrenees, but not so frequently as in the Alps. It is frequent in the mountains of Silesia, Saxony, the Fichtelgebirge, &c.

It is common in the mountains of the United States of America. It occurs in the mountains of Valentiana in Mexico, where it alternates with beds of sienite, primitive-trap, and clay-slate; and in the island of Cuba it is associated with sienite.

8. *Uses.*—It is cut and polished, and used as an ornamental stone.

VIII. *Euphotide.*

Euphotide.—*Hauy.*
Euphotide.—*Jameson.*
Gabbro of the *Italians.*
Diallage Rock of others.

Constituent parts.—It is a compound of saussurite and diallage, and these two minerals are sometimes intermixed with talc, hornblende, actynolite, garnets, grains of pyrites, &c.

Geographical distribution.—It occurs along with serpentine in the Shetland islands and in Cornwall. Von Buch found it in great abundance in Norway, even as far north as the North Cape, and it has been met with in Germany, Switzerland, and Italy.

Uses.—When cut and polished, it presents a very beautiful surface, hence it is much esteemed in some countries, as Italy, as an ornamental stone. The *nero di prato, verde di prato, granito di gabbro*, of the Italians, are either varieties of euphotide, or serpentines with disseminated metalloidal diallage.

IX. *Porphyry.*

Porphir.—*Werner.*
Porphery.—*Kirwan.*
Porphyry.—*Jameson.*
Porphyre.—*Brochant and Daubuisson.*

1. *Name.*—The Grecian word from which the name porphyry is derived, signifies *red*; hence the name of the formation is borrowed from that kind, which is denominated Antique Red Porphyry. It is worthy of remark, that red, or colours bordering on it, or passing into it, prevail in rocks belonging to the porphyry formation.

2. *Composition and varieties.*—It is a compound rock, having a basis, in which the other cotemporaneous constituent parts are imbedded, either in the form of grains or crystals. Neither the base nor the imbedded parts are always of the same kind. On the differences of the first, depends the distinction of the different kinds of porphyry. The base is sometimes claystone, forming *claystone porphyry*, hornstone forming *hornstone porphyry*, compact felspar forming *felspar porphyry*, pitchstone, when it is named *pitchstone porphyry*; and if it contains much hornblende, it has been named *sienitic porphyry.* The imbedded parts are most commonly felspar and quartz, which are usually more or less perfectly crystallized. The quartz is usually crystallized, and in double six-sided pyramids. The felspar crystals are broad six-sided prisms, but usually very indistinct. The felspar is more or less fresh, sometimes even glassy, sometimes completely disintegrated and earthy, or only in white specks. The frequency and magnitude of these mixed parts, of quartz and felspar, modify the appearance of the different kinds of porphyry very much. Sometimes one, sometimes the other, but more frequently both occur together, and along with several other minerals which are less frequent, as crystals of hornblende and mica. The basis and the mixed parts of the porphyry also differ in colour and several other properties. It sometimes contains chalcedony and agate,

which are in massive pieces, or in small layers or plates. Further, there sometimes occur balls of a greater or less size; in clay-porphyry the centre of these balls is chalcedony, but their exterior is hornstone porphyry; but in pitchstone-porphyry, these balls are composed of a particular kind of conchoidal hornstone, but the centre is quartz. It sometimes also contains precious and common opal, and these are either disseminated through it, or traverse it in the form of very small veins.

3. *Structure.*—Porphyry is seldom stratified, and when it is stratified, the strata are very indistinct. It is usually either massive, and merely traversed by numerous accidental rents, or disposed in distinct concretions, which are tabular and columnar, or they are globular, and these again are composed of concentric lamellar concretions.

4. *Foreign beds.*—It contains few foreign beds, with exception of granite, gneiss, and greenstone, which are intermixed with it. One of the best examples of porphyry with foreign beds is that given by Beudant, who describes three different sorts of beds in the sienitic porphyry, in the environs of Schemnitz in Hungary. These are, 1. Small beds of mica-slate that alternate with small granular sienite. 2. Beds of quartz. 3. Beds of compact limestone impregnated with steatite, and intermixed with serpentine.

5. *Metalliferous minerals.*—It contains many metalliferous minerals. They occur more frequently in veins than in beds; but as the porphyry is seldom stratified, and as the surface of superposition is not often seen, it is difficult to determine to which of the two kinds of repositories they belong. The richest mines at present known, those of Mexico, are situated in enormous veins that traverse sienitic porphyry. The mines of Hungary, the most considerable on the continent of Europe, are situated in the same kind of porphyry; and it would appear that the famous mines of Cyprus, so much extolled by the ancients, were also in porphyry. The numerous veins of lead, copper, and silver, worked at Giromagny, in the Vosges, are in a porphyry tract.

6. *Formations.*—Porphyry occurs in imbedded masses, beds, and veins of granite, gneiss, mica-slate, and clay-slate.

7. *Form of mountains.*—They are often conical, sometimes like truncated cones, or appear dome-shaped.

8. *Geographical distribution.*—It occurs in the Shetland islands, in several of the Hebrides, and on the mainland of Scotland, in Sutherland, Ross-shire, Inverness-shire, Perthshire, &c. In England it is met with in Cornwall, and in other districts. On the continent of Europe, it occurs in Sweden; it forms a part of the Vosges, and rises in mountains in the granite district of Forez, also in France. It has not been met with in the Pyrenees, nor is it mentioned as occurring in the Alps of Switzerland, nor in the northern side of the grand chain of the Alps, but it occupies a considerable tract on the southern side, from the lake of Como to Carinthia and Carniola. It appears, although not very abundantly, in Silesia, Saxony, and Thuringia, and forms extensive tracts in Hungary. It abounds in some districts in Upper Egypt, Siberia, and in North and South America.

Uses.—It was formerly used extensively in ornamental architecture, and is still worked in considerable quantity as an ornamental stone, in Elfdal in Sweden, where there are considerable quarries of porphyry.

X. *Quartz Rock.*

Quartz fels.—*Werner.*
Quartz Rock.—*Jameson.*
Quartz en Roche.—*Daubuisson.*
Quartzite.—*Brongniart and Bonnard.*

1. *Characters.*—Quartz occurs not only as an essential constituent part of granite, gneiss, and mica-slate, and disseminated in beds and veins in these rocks, but also in mountain masses and mountains. Quartz-rock, properly so called, is generally of a white colour, and sometimes reddish or bluish. It has a granular structure; the concretions vary from the smallest size, visible to the naked eye, to that of an egg, or even larger; or it is compact. It frequently contains grains of felspar, and also scales of mica. When the felspar and mica increase in quantity, it passes into granite, or into gneiss, when only the mica into mica slate.

Structure.—It occurs either distinctly stratified, or massive, and without the stratified structure.

2. *Metalliferous minerals.*—It often contains disseminated iron pyrites, and occasionally lead-glance, copper-pyrites, and blende.

3. *Form of mountains.*—Mountains of quartz-rocks are often conical, sometimes even peaked, or they are crenated.

4. *Geognostic situation.*—It occurs in beds and mountain masses, in granite, gneiss, mica-slate, and clay-slate, and indeed in a certain degree associated with most of the rocks of the primitive series.

Geographical distribution.—It abounds in many districts in Scotland, as in the islands of Jura and Isla, the Shetland Islands; on the mainland, in Sutherland, Caithness, Inverness-shire, Argyleshire, &c.

Class II. Transition Rocks.

Ubergansgebirge.—*Werner.*
Transition Rocks.—*Jameson.*
Terrains Intermediaires.—*Daubuisson.*

The rocks of the primitive class, as already remarked, are distinguished in a general view by their highly crystalline structure, and want of petrefactions, or fossil organic remains. In some countries we observe resting upon them, and even alternating with them, a series of rocks, of which clay-slate is a predominating member, having less of the crystalline aspect, and which contains fossil organic remains. Werner considers this set of rocks as interposed between the grand series of primitive and secondary rocks; and that, although it occasionally alternates, on the one hand, with the primitive, and on the other with some members of the secondary class, still its characters are so well marked, that he views it as a distinct class, to which he gave the name *Transition*, from its forming, as it were, the transition or passage from the primitive to the secondary rocks. Although some mineralogists have abandoned this view, and now arrange the transition rocks along with those of the primitive or secondary classes, we are still inclined to consider them as deserving a separate place in the geognostic system. It is true, that the transition rocks are but a continuation of the primitive, and, on a general view, might with propriety be considered as a portion of that series; but their imbedded fossil organic remains, less crystalline aspect, and particular rocks, such as grey-wacke, appear to characterise them, if not as a distinct class, yet as a separate group in the grand series of rock formations.

The following are the rocks of this class:

1. Grey-wacke.
2. Transition limestone.
3. Granite and porphyry.
4. Gneiss, mica-slate, &c.
5. Serpentine.
6. Quartz-rock.
7. Red sandstone.
8. Transition-trap.
9. Gypsum.

I. *Grey-wacke.*

Grauwacke.—*Werner.*
Greywacke.—*Jameson.*
Traumate.—*Daubuisson.*
Psamite.—*Brongniart.*
Breche, Poudingue, and Gres, *of some French geologists.*

Composition.—It is composed of angular or other portions of quartz, felspar, Lydian-slate, and clay-slate, connected together by means of a basis or ground of the nature of clay-slate, which is often highly impregnated with silica, thus giving to the mass a considerable degree of hardness. The imbedded portions vary in size, but seldom exceed a few inches in breadth and thickness. When the imbedded portions become very small, the rock assumes a slaty structure, and forms the *Grey-wacke slate* of geognosts. When the grains almost entirely disappear, and the rock is principally composed of clay-slate, it is named *transition clay-slate*. This clay-slate has frequently a much more earthy aspect than the varieties found in the primitive districts. Besides the grey-wacke already described, which has the conglomerated structure, another, having the same structure, is occasionally met with in transition districts. It has been named *transition conglomerate*, or *pudding-stone.* It is composed of roundish or angular masses of granite, porphyry, gneiss, and clay-slate, often larger than a man's head, imbedded in clay-slate, or nearly without a basis or ground.

Common grey-wacke does not occur so frequently as greywacke slate and transition clay-slate.

Subordinate beds.—Transition clay-slate, and greywacke, contain occasionally different kinds of rocks in subordinate beds, or in veins. The following are the principal of these:

1. *Quartz.*—It occurs in beds, imbedded masses, and veins, and frequently in very considerable quantity.

2. *Talc.*—This mineral occurs in imbedded masses, and in layers in transition clay-slate. There is a fine example of it in the clay-slate of Glaris, in Switzerland, which is remarkable for the petrified fishes it contains.

3. *Whet-slate.*—This mineral forms beds in the clay-slate.

4. *Serpentine*—Beds of serpentine, often of great thickness, and of considerable extent, occur along with transition clay-slate.

5. *Lydian stone.*—Beds of this rock occur in clay-slate.

6. *Alum slate.*—This rock is clay-slate impregnated with carbon and sulphur. The sulphur is either combined with the carbon, or united with iron, forming iron pyrites. On exposure to the weather the sulphur becomes oxygenated, is converted into sulphuric acid, which acts on the alumina of the slate, and thus forms a sulphate of alumina.

7. *Drawing slate*, or *black chalk.*—This also is clay-slate, but more highly impregnated with carbon than the alum-slate. When soft, it is cut, and forms crayons for sketching.

8. *Glance coal.*—This mineral occurs in beds subordinate to clay-slate and greywacke, which sometimes contain vegetable impressions. Of this, there are examples in Switzerland and in the kingdom of Saxony.

9. *Compact felspar.*—Beds of this mineral occur in the transition clay-slate and greywacke of Dumfries-shire, and along with rocks of the same description in France, Italy, and Spain.

10. *Greenstone.*—This rock is met with in the transition ranges in the south of Scotland, and in similar mountains on the continent of Europe.

11. *Vegetable remains.*—Transition clay-slate occasionally contains vegetable impressions, particularly those varieties which are associated with glance coal. Animal remains are seldom met with in the clay-slate, and still less frequently in the grey-wacke. These are *madreporites*, *trilobites*, *ammonites* of a particular description, and *hysterolites*, which are, in some degree, characteristic of this formation, and which appear to be the nucleus of the *terebratulites valvarius*, and *paradoxus.* It sometimes also contains *turbinites* and *camites.* But the rarest and most interesting of the animal remains which occur in transition clay-slate, are those of *fishes*, of which there is an instance at Plattenberg, two leagues south-east of Glaris, in Switzerland. This fact is stated by several geologists, but we are of opinion, that it has not been fully proved that the rocks of Plattenberg are truly transition.

Metalliferous Minerals.—Ores of various descriptions abound in greywacke and transition clay-slate; thus the lead mines of Leadhills, and of Wanlockhead, are situated in these rocks, and the same is the case with the productive lead and silver mines of the Hartz in Hanover, of Vorespotack in Transylvania, of Brittany in France, and of Guanaxuato and Zacatecas in Mexico.

Geographical Distribution.—Grey-wacke and transition clay-slate abound in all the mountain ranges to the south of the Frith of Forth, are also frequent to the north of the same boundary, and are widely distributed in England. On the continent of Europe, they form a principal feature in the mountains of the Hartz, extend through Switzerland and the Pyrennees, and occur in vast abundance both in North and in South America.

II. *Transition Limestone.*

Übergangs Kalkstein.—*Werner.*
Transition Limestone.—*Jameson.*
Calcaire Intermediaire.—*Daubuisson.*

1. *Characters.*—This limestone is in general more compact than that met with in decided primitive districts; yet it is not always so, for it occasionally occurs, is coarse granular or highly crystallized. Its fracture is, in general, splintery, usually combined with very minute foliated, and is translucent on the edges. It varies very much in colour. It is often black, and frequently many colours occur together, these forming what are termed *variegated marble.* Many of the varieties are traversed by small cotemporaneous veins of cal-

careous spar. Most of the ornamental marbles used in architecture belong to the transition class, while the statuary marbles are of primitive, and the coarser marbles of secondary formation.

2. *Subordinate Beds and Imbedded Minerals.*—(1.) *Lydian Stone.*—It occurs abundantly in the bituminous transition limestones in the north of France, where it is disposed, either in irregular masses like flint in chalk, or it forms small plates or tables, or it alternates in beds. The same disposition is met with in the transition limestones of the Pyrennees, Alps, &c.

(2.) *Mica* occurs disseminated or in layers, and sometimes associated with talc or steatite.

(3.) *Quartz.*—It occurs disposed in veins, beds, or disseminated, and sometimes in the form of rock crystal.

(4) *Pyrites.*—This ore is generally denominated,

(5) *Brown Ironstone.*—Occurs in veins and beds.

(6) *Glance-coal.*—Some black transition limestones are highly impregnated with carbonaceous matter, which is sometimes accumulated in particular points, and thus forms imbedded masses of glance-coal, of which there are examples in the north of France.

3. *Petrifactions.*—Fossil organic remains occur but rarely extensively distributed in this rock, but are sometimes abundantly accumulated in particular situations. Petrified madrepores, millepores, orthoceratites, and terebratulites, are the most frequent, and along with these are some entrochites, encrinites, turbinites, ammonites and belemnites.

4. *Geographical Distribution.*—It occurs in Scotland, near the Crook, on the road to Moffat, and in other quarters, both to the south and north of the Frith of Forth. On the Continent, it occurs at Christiania in Norway; in many places in the Hartz, as at Blankenburg, where there are extensive marble quarries, which afford a marble equal to that named *rosso corallino*; in Italy; in the country of Bareuth, in Saxony, where there are several beautiful varieties, one of a black colour, with fragments of entrochi, which nearly resembles the *nero d'Egitto* of the Italians. Werner remarks of this petrifaction, that it occurs most frequently in black marble, while petrified corals are most common in those of a red colour. In the south of France, and in the Pyrennees, it is a very abundant rock; while in the north of France it forms a part of the great transition zone which extends from Flanders to the Hartz. The north side of the Alps, from France to Hungary, is bounded by an enormous deposite of this limestone.

III. *Granite, Sienite, and Porphyry.*

These rocks, which are so nearly allied to each other, occur in considerable abundance in some districts where the predominating rocks are greywacke and clay-slate. The nearest point to Edinburgh where these rocks occur, is Fassneyburn, about 12 miles from Haddington, where transition granite, and porphyry, and also sienite, are met with. These rocks are also found in Galloway, and in other parts to the south of the Frith of Forth. To the north of the Forth, we may mention the vicinity of Macduff in Banffshire, as an example of transition-granite. On the Continent, one of the most striking displays of these rocks occurs in the vicinity of Christiania in Norway, where the following arrangement was detected by Von Buch and Hausmann.

1. Gneiss. 2. Transition clay-slate and limestone. 3. Granite. 4. Clay-slate and limestone. 5. Greywacke-slate. 6. Flinty slate. 7. Sandstone. 8. Porphyry. 9. Granite. 10. Sienite, with imbedded crystals of zircon.

In this series, the gneiss is the undermost, while the zircon-sienite forms the uppermost bed of the series. The limestone, in some places, is white and highly crystallized, and contains tremolite, epidote, garnet, blende, &c. but more frequently it is black and compact, and contains orthoceratites, some feet in length, along with pectinites, chamites, trilobites, &c.

Similar arrangements have been observed in other parts of the world.

IV. *Gneiss, Mica-slate.*

These rocks occur in small quantity, associated with greywacke and greywacke-slate, in the alpine land to the south of the Frith of Forth, and even in some districts to the north of the Forth. An arrangement of the same description is described by Brochant as existing in Switzerland.

V. *Serpentine.*

In some districts in the Alps, serpentine occurs in beds in transition rocks.

VI. *Quartz-Rock.*

It occurs in beds and in mountain masses, along with clay-slate and greywacke, not only on the Continent, but also in this island.

VII. *Red Sandstone.*

This rock, which is very nearly allied to quartz-rock, occupies the same position as that rock in the transition series.

VIII. *Transition Trap.*

Übergangstrapp.—*Werner.*
Transition Trap.—*Jameson.*
Amphibolite.—*Daubuisson.*

The transition trap-rocks are amygdaloid, greenstone, and basalt. These occur in beds and in imbedded masses in Dumfries-shire, and other transition districts in the south of Scotland. In England, they occur in beds along with the alpine limestone, as in Derbyshire and other districts. In Ireland it forms beds also in a limestone which appears to belong to the transition series. The trap-rocks of Oberstein, on the Rhine, of Voightland, also belong to the transition class.

IX. *Gypsum.*

Transition gypsum, according to Brochant, is generally white, very fine granular or compact, and contains particles of calc spar, scales of mica and talc, and portions of rock-salt and of sulphur. He refers the gypsum of Pesey to this class; also that of Brigg in the Vallais, which is covered with a granular micaceous limestone, and also the deposite in the Val-Canaria. The transition clay-slate of Salzburg also contains beds and imbedded masses of gypsum. M. Von Charpentier is of opinion, that the saliniferous gypsum of Bex is situated in beds in a transition limestone.

Class III. Secondary, or Flœtz Rocks.

Flœtz gebirge.—*Werner.*
Secondary, or flœtz rocks.—*Jameson.*
Terrain Secondaire.—*Daubuisson.*

Secondary rocks, in the regular succession, rest on those of the transition class; and sometimes the older rocks of the series, alternate with clay-slate and other members of the preceding class. They are less crystalline than primitive and transition rocks, and are particularly characterised by the number, variety, and abundance of fossil organic species which they contain. The principal secondary rocks are, sandstone, limestone, gypsum, and trap.

We shall now describe the different formations of these sandstone, limestone, gypsum, and trap rocks, beginning with sandstone.

1. *Sandstone.*

This rock is formed of angular or roundish grains of different minerals, connected together by means of a basis or ground, or immediately joined without any basis. When the grains are not larger than a hazelnut, the compound is simply named sandstone, but when they exceed that magnitude, they are denominated *conglomerate*, if the masses are roundish; but *breccia*, if angular. Sandstone is divided into three kinds, named *siliceous*, *argillaceous*, and *marly* or *calcareous*. In the siliceous kind, the particles are connected by a ground or basis of quartz; in the argillaceous by a basis of clay, which is sometimes highly impregnated with red oxide of iron, and gives a red cast to the whole rock; and the particles in the marly or calcareous kind are set in a marly or calcareous basis.

The following are the formations of sandstone:

I. First, or red sandstone, with the coal formation.
II. Second, or variegated sandstone.
III. Third sandstone, or quartzy sandstone.
IV. Fourth sandstone formation.

I. *Red Sandstone, or Old Red Sandstone.*

Œlter, rother Sandstein.—*Werner.*
Old Red Sandstone.—*Jameson.*
Rothe-todte-liegende.—*German Miners.*
Gres Ancien.—*Daubuisson.*

1. *Characters.*—The predominating colour of this rock is reddish-brown; but some varieties are grey, and others white. It occurs in the form, not only of sandstone, but also of conglomerate and breccia. The grains in the sandstone are principally quartz, with occasional intermixtures of felspar, flinty slate, and scales of mica; the roundish and angular masses in the conglomerate and the breccia are frequently of quartz, or of granite, gneiss, mica slate, clay slate, porphyry, sienite, quartz-rock, &c. The basis or ground is generally an iron-shot clay, or it is composed of smaller particles of quartz or felspar, as is often the case in the conglomerates and breccias. The basis is sometimes highly impregnated with silica, and then it is very hard; and, in other varieties, it has a porphyritic character.

2. *Subordinate Beds and Veins.*—It contains beds and veins of porphyry, sienite, quartz-rock, clay-slate, limestone, and various trap-rocks, such as amygdaloid, greenstone, basalt, trap-tuff, and pitchstone.

3. *Petrifactions.*—Very few animal remains occur in this formation, although it frequently alternates with a limestone, which contains abundance of marine shells, and other similar organic productions. But petrified vegetables are not so uncommon, and these are generally of trunks and branches of trees belonging to the monocotyledonous class, as is proved by their being composed of simple longitudinal fibres without concentric rings.

4. *Metalliferous Minerals.*—The principal metals found in this formation are iron, copper, and lead. The iron ores are the brown and red; the copper ores, pyrites, and blue copper; and the lead, galena or lead glance.

5. *Geognostic Situation.*—In Scotland and Ireland, it is observed resting on primitive and transition rocks. The same arrangement occurs in Germany, and in other countries on the continent of Europe.

6 *Geographical Distribution.*—It forms considerable tracts of country in Scotland.

Observation.—The transition red sandstone, which is connected with quartz-rock, is often so nearly allied to the present formation, that it is doubtful if they do not belong to the same series.

Coal Formation.

Coal-measures, or coal-field.—*English miners.*
Steinkohlengebirge.—*Werner.*
Terrain houiller.—*Daubuisson.*
Terrain à charbon de terre.—*Older French Geologists.*

This very interesting and important formation consists of a considerable number of different rocks. The following may be enumerated: 1. Coal. 2. Slate. 3. Sandstone. 4. Quartz-rock 5. Limestone. 6. Ironstone. 7. Clay. 8. Trap. 9. Graphite. Of these rocks, the most frequent are, the sandstone, slate, ironstone, and coal; the others, from their comparative rarity, may be viewed as subordinate members of the formation.

1. *Coal.*—Two species of coal are found in this formation, viz. *black coal*, and *glance coal*, or *blind coal;* the former has a resinous lustre, and is bituminous, and burns with much flame and smoke; while the other is not bituminous, has a metallic lustre, and burns without flame and smoke.

This mineral, whether black coal, or glance coal, occurs only in beds which vary in thickness from a few inches to several yards; and there are rare instances of their attaining a thickness of three hundred feet, as in the vicinity of St. Aubin, in Rouergue; but in this case, the coal is disposed rather in enormous imbedded masses, or kidneys, than in true beds. The thickness of the beds often continues wonderfully regular for a great extent; but in others, they contract and expand in the line of direction; so that, in the course of the same bed, the thickness will vary from an inch to several yards.

2. *Slate.*—Under this head, we include bituminous shale, slate-clay, and flinty slate.

a. Bituminous Shale.—This mineral is clay, more or less impregnated with coally matter, of a black colour, with a slaty fracture, and affording a shining resinous streak. It frequently contains impressions of reeds and ferns. It passes into coal, is frequently intermixed with it, or alternates in beds, often of considerable magnitude, with the other rocks of the coal formation.

b. Slate Clay.—This rock is of a grey or black colour, with a slaty fracture, and affords a grey dull streak. It sometimes contains scales of mica, and grains of quartz and felspar; and when these increase in quantity, it passes into sandstone. It frequently contains *vegetable impressions*, which are principally of ferns and reeds.

Like bituminous shale, it alternates in beds of various magnitudes, with the other rocks of the coal formation.

c. Flinty Slate.—The slate-clay is sometimes highly impregnated with silica, and then it is very hard and flinty-looking, and passes into the mineral named Flinty Slate. Imbedded masses, and beds of flinty slate, occur in the slate-clay, and occasionally associated with other members of the coal formation.

4. *Sandstone.*—The predominating mineral in this sandstone is quartz, in granular concretions, which is variously intermingled with flinty slate, felspar, mica, and portions of different species of rock of the primitive species; all of which are generally connected together by a basis or cement of a grey-coloured and earthy aspect. Sometimes the earthy basis is wanting, when the grains are joined together, in the same manner as in granite, and other rocks of the same description. The constituent parts are sometimes so large as to form conglomerates and breccias; but generally they are small, and when much intermixed with clay, pass into slate-clay; and then they contain more vegetable impressions than usual.

4. *Quartz.*—This mineral, in the form of quartz-rock, sometimes occurs in beds.

5. *Limestone.*—A grey-coloured compact limestone sometimes occurs in considerable beds, in coal-fields, and alternates with the various rocks of the formation. In some districts the limestone is abundant; in others it is rare; and in many it is entirely wanting. It occurs in the coal fields near Edinburgh, and in those in the north of England.

6. *Iron Stone.*—This iron-stone, which is sometimes carbonate, sometimes hydrate of iron, occurs in beds that alternate with slate-clay, or bituminous shale, or it is disposed in balls and lenticular masses, either irregularly, or in regular rows in the strata. It is a very abundant mineral in most of the coal-fields in Scotland and England, and affords nearly all the iron of commerce produced in Great Britain.

7. *Clay.*—The different kinds of fire-clay, so well known in the arts, occur in beds in the coal formation.

8. *Trap and Porphyry.*—Different species of these rocks are met with in the coal-fields of Scotland, and of other countries. We have observed the following, viz. *Greenstone*, *Amygdaloid*, *Basalt*, *Trap-tuff*, and *Porphyry*, in beds and in veins varying in magnitude and extent.

9. *Graphite*, or Black Lead.—Beds of graphite occur but rarely in this formation. There are examples of this arrangement in Ayrshire.

Arrangement of the beds in the Coal Formation.—Although no very regular arrangement of the beds occurs in this formation, nevertheless it has been remarked, that in some districts beds of coal are generally contained in the slate, and that as we recede from the coal the slate becomes coarser and coarser, and at length passes into sandstone; in others, the sandstone most generally forms the floor, while the roof is of slate: and in others the coal is covered with trap or limestone, or rests upon these rocks.

In many coal-fields, the beds of coal and their accompanying rocks are frequently repeated in precisely the same order, and in nearly the same thickness.

The number of beds of coal superimposed on each other in the same field is very considerable. At Newcastle, twenty-five beds have been penetrated in sinking pits. The hill of Dutweiler in Saarbruck, contains thirty-two beds; at Liége, there are sixty beds; and at Anzin more than fifty.

Identity of Character of the Formation in different countries.—In Scotland, the predominating and characteristic members of the formation are sandstone, bituminous shale, slate-clay, clay ironstone, and coal. In England, we find in all the coal-fields precisely the same sandstones, slates, ironstones, and coals, as in Scotland; and the same is the case in all the coal mines of France, Germany, and America. Every where we meet with the same rocks, the same vegetable impressions, and the same general arrangements of the different rocks of the formation.

Stratification.—All the rocks of this formation are stratified, some more, and others less, distinctly. The most perfectly stratified are the sandstone and slate; and those having this structure in the most imperfect degree, are the trap and porphyry rocks. The strata often follow every inequality of the fundamental rock on which they rest; and as the surface of the fundamental rock is frequently remarkably uneven, the superimposed strata acquire a very irregular and contorted aspect. In some cases the strata do not appear to follow the inequalities of the fundamental rock, but have directions that appear independent both of the surface of the rock, and of the cavity or hollow in which they are contained.

Situation.—The rocks of this formation are generally situated at the foot of mountains, or in basin or trough-shaped hollows, which vary from a few hundred yards to many miles in extent. It seldom rises high above the level of the sea, and the countries it forms have generally a waved and soft outline. In this island it rests either on the mountain limestone or red sandstone, and is covered by magnesian limestone and other newer formations.

Dikes.—The strata of this coal formation are frequently traversed by veins, which are composed of earthy minerals, and are named *Dikes*. These dikes are sometimes only a few inches wide, and not many fathoms in extent; in other cases they are upwards of one hundred feet wide, and extend for some miles. Their direction varies, as also their angle of inclination, which latter ranges from the nearly horizontal to the vertical position. The strata in the walls of the dikes, in some cases, correspond on opposite sides, while in others the corresponding strata on the hanging side are depressed some feet, or even fathoms, so that miners, in working a bed of coal for example, when stopped in their progress by a dike, do not find it directly opposite on cutting through it, but some feet or fathoms out of the line of bearing of the bed. When the strata present such an appearance, they are said to *be shifted*. The materials of these dikes, or veins, varies, as appears from the following enumeration of the rocks of which they are sometimes formed: Greenstone, amygdaloid, trap-tuff, porphyry, sandstone, and fragments of the various surrounding strata. The strata, where in contact with dykes, appear sometimes of a different nature from the other parts of their mass; thus beds of coal, where in contact with the dike, appear as if charred, slate-clay hardened, and sand and lime indurated; yet in the midst of these apparently changed portions, there occur unaltered minerals, such as calcareous spar, iron pyrites, and clay.

Metalliferous Minerals.—The ores most frequently met with in this formation are, clay iron ore, and galena, or lead-glance. The iron ore occurs every where in the coal-fields of this island; but the lead-glance is found in quantity only in the coal-districts in the north of England, and in Wales. Copper, silver, and even gold, are enumerated among the metalliferous productions of this formation; and it would appear that cinnabar or sulphuret of mercury is sometimes also contained in it.

Petrifactions.—Mineralized organic remains are not unfrequent in the coal-fields of different countries; and it is worthy of remark, that hitherto the same tribes and species have been met with in the coal formations of Great Britain, Ireland, Germany, and France. Both vegetable and animal remains occur, but of these the former are by far the most varied and abundant. The impressions of plants are frequent, both in the slate-clay and bituminous-shale; and we cannot recollect a coal-mine where these rocks have not been found to contain organic vestiges of this description. Many belong to the monocotyledonous class of plants, and are principally aquatic, such are the *large reeds* and *bamboos;* besides these, we meet with numerous remains of *ferns*, and species of the genera *lycopodium, equisitum, euphorbia, casuarina, &c.* Impressions of the branches and fruit of palms, or of vegetables resembling this tribe, are also occasionally met with. None of these plants are identical with any of the present known living species; and many of them have a tropical aspect.

These vegetable remains seldom occur in the coal, but are abundantly distributed in the slate, particularly where it is near the surface of the bed of coal; and the most frequent remains are those of leaves or of flattened trunks, sometimes changed into coal, enclosed in the layers of the slate; but in other instances the reeds, and other vegetables of large diameter, are upright, and are filled with clay, or with the same substances as that in which they are contained.

The animal remains found in the coal formation are principally of shells, and of these the most frequent are those which resemble the fresh water species; such are the different species of mytulites.

Origin of Coal.—Two opinions are entertained in regard to the origin and formation of coal. According to the one, it is of vegetable origin; and according to the other, it is an original chemical formation. Its chemical properties, and numerous accompanying vegetable remains, which are sometimes changed into coal, are the principal facts adduced in favour of its vegetable origin; while its distribution in regular conformable beds, its occurrence in veins, and embedded masses, its manifold alternations and connections with different strata, some of which never contain vegetable remains, its rhomboidal structure, external characters, its connection with glance coal on the one hand, and with bituminous shale and sandstone on the other, are the appearances which are considered as illustrating its formation as an original deposit, from a state of chemical solution.

II. *New Red or Variegated Sandstone.*

Bunter Sandstein.—*Werner.*
Red Ground—*English Geologists.*
New Red.—*Buckland.*
New Red or Variegated Sandstone.—*Jameson.*
Second formation de Gres, et Gres avec argile.—*Daubuisson.*
Gres Bigarre.—*French Geologists.*

Characters.—It is small granular, with an argillaceous, or marly basis. Its colour varies extremely, being frequently disposed in bands or zones, of red, grey, green, yellow, and brown, hence the name variegated, given to it by Werner. These different colours are owing to the different states of oxidation of the iron in the basis or cement, but it may be remarked, that these deep colours are often very superficial, the interior of the rock being of a grey or white colour, while the exterior, by exposure, becomes brown or red.

This sandstone frequently contains masses of variously-coloured clay or marl, which are often lenticular, and vary very much in size, and contribute very much to increase its liability to decomposition. The clay is sometimes greasy to the feel, and forms a kind of fuller's earth. Although the most common cement or basis of this sandstone is clay, yet some beds have a marly, and others a quartzy basis.

It sometimes contains mica, and sometimes in such quantity that sandstone passes into sandstone slate.

It alternates with beds of a red-coloured clay, or marl, which is often slaty, and generally intermixed with sand and mica, and sometimes passes into sandstone slate. These beds are sometimes of great thickness, and from their being frequently short, and very thick, appear like great imbedded masses. Sometimes the marly or calcareous basis increases so much, that the sandstone passes into limestone. The colouring principle in the clay is occasionally so abundant in some parts of the beds, that a red crayon is formed. The thick beds of clay occur principally towards the upper part of the formation, which indeed is principally red clay. Sometimes beds of conglomerate occur associated with the sandstone, marl, and clay.

Subordinate Beds.—1. *Limestone.*—Beds of limestone are met with in this formation; but, in general, the limestone is very impure, being mixed with clay and sand; and thus forms a more or less arenaceous marl.

2. *Oolite* or *Roe-stone.*—This curious kind of limestone occurs but in small quantity, and generally in beds varying from a few inches to two or three feet in thickness.

3. *Iron Ore.*—It sometimes occurs in considerable quantity, and is generally the red ore. It is either in imbedded portions, disseminated, or so minutely diffused, as to colour some of the sandstones of a deep red colour.

4. *Heavy Spar, Sulphate of Barytes.*—This mineral occurs in veins in the sandstone.

5. *Celestine*, or *Sulphate of Strontites.* This mineral occurs in the clay and sandstone, in the form of veins and beds, near Bristol.

6. *Gypsum.*—It occurs in imbedded masses, and beds and veins, in the marl or sandstone of this formation.

7. *Rock Salt.*—The salt of the principal salt mines in Europe is arranged in beds, and imbedded in this formation.

8 *Copper Ore.*—Traces of copper ore are rarely met with in this formation.

9. *Coal.*—This mineral occurs very rarely, and usually in inconsiderable beds.

10. *Petrifactions.*—The most frequent petrifactions are pectinites, pinnites, pholades, turbinites, and large ostracites; and sometimes petrified wood, and impressions of leaves.

Geognostic Situation.—It rests upon the magnesian or second limestone, and sometimes even alternates with it, and is immediately covered with the oolite formation.

Geographical Distribution.—It is a very widely distributed formation in England, extending, with little interruption, from the northern bank of the Tees in Durham, to the northern coast of Devonshire: Also occurs in Scotland, particularly in the southern division.

III. *Third Sandstone Formation.*

Green Sand of *English Geologists*.
Third Sandstone Formation.—*Jameson.*
Troisieme Formation de Gres.—*Daubuisson.*
Quader-Sandstein.—*Werner.*
Gres presque entièrement quartzeux.

This formation, the characters of which are still but imperfectly known, is described by English geologists, under the name Green-sand, and, according to Mr. Buckland, is associated with various strata.

Characters.—The sandstone is composed of particles of white quartz, which are either cemented by a calcareous basis, or are united without any cement, and frequently contain scales of mica, and embedded grains, and portions of a green substance, of the nature of chlorite or augite.

The quartzy particles are sometimes so arranged and connected, that the sandstone is as massive and compact as quartz, while, in other instances, it occurs in the state of loose grains or sand.

It frequently contains imbedded cotemporaneous masses of *chert*, and the same mineral occurs also in beds; and sometimes both the green-sand and chert are traversed by veins of calcedony.

Subordinate Beds.—Limestone of a blue and reddish colour, in the form of beds, is occasionally met with, and sometimes the limestone is also distributed through the sandstone in masses of varying magnitude. Mr. Buckland enumerates the following beds as occurring in this formation: 1. Lead-coloured clay; 2. Micaceous and sandy blackish clay, with disseminated green earth; 3. Iron-sand, usually red and yellow, and containing subordinate beds of clay, ochre, and fuller's earth, either pure, or inclosing nodules of heavy spar.

Petrifactions.—It contains musculites, mytillites, and tellinites, and sometimes impressions of leaves and stems resembling those of the palm tree and the pine.

Coal.—It sometimes contains beds of coal, but these are in general so thin, as to be of no value in an economical point of view.

Geognostic Situation.—It rests upon the upper oolite, and is covered by the chalk formation.

Geographical distribution.—It occurs abundantly in England, as in Wilts, Dorset, Sussex, Devon, Oxford, Isle of Wight, Surrey, &c. And on the Continent of Europe it is met with, both in Upper and in Lower Saxony.

IV. *Fourth Sandstone Formation.*

This formation is associated with the rocks that rest upon chalk, and will, therefore, be described along with these.

II. *Secondary or Flœtz Limestone.*

The limestones of this series are more compact and less translucent than those of the transition class; and further, they abound much more in organic remains of different kinds. The following are the formations which have been enumerated by authors, viz.

I. First Secondary Limestone.
II. Second Secondary Limestone.
III. Third Secondary Limestone.
IV. Fourth Secondary Limestone.
V. Fifth Secondary Limestone.

I. *First Secondary Limestone.*—Jameson.

Premier formation du Calcaire Secondaire. *Daubuisson.*

Alpine and Jura Limestones of German and some French Geologists, Mountain Limestone of English geologists.

Characters.—The colours of this limestome are grey, blue, and black. Its lustre varies from glistering to dull; the fracture is splintery, or granular foliated; and it is opaque or translucent in the edges. Some of the varieties are *stinkstone*, while the black varieties are those known under the name *lucullite*, and both these, when pounded, emit a very disagreeable smell.

It is distinctly stratified, and the strata are sometimes undulated and contorted.

Caves and caverns are not unfrequent in this formation, and extensive fissures frequently trasverse it, which either reach to the surface, or extend to a greater or less distance under ground, and afford channels for great springs and subterranean rivers.

It frequently contains imbedded portions and beds of Lydian stone, of quartz in the form of *chert*, which is either of a grey or black colour, and very much resembles the flint in chalk in the various relations it bears to the limestone.

Petrifactions are not unfrequently met with in this formation; and the following are the kinds which have been found in England, viz. entrochites, tubeporites, encrinites, corallites, madreporites, ammonites, pectinites, orthoceracites, &c.

Subordinate beds.—These are amygdaloid, greenstone, trap tuff, and basalt; also sandstone, magnesian limestone, slate-clay, bituminous shale, coal, and clay.

Metalliferous minerals.—This formation in some districts, as in the north of England and in Derbyshire, is particularly abundant in ores of different descriptions. The lead mines of Northumberland and Durham, and the lead and copper mines of Derbyshire, are situated in mountain limestone.

Geognostical position.—In what is called the regular succession, it comes immediately after the old red sandstone, and therefore rests upon it.

Geographical distribution.—It abounds in the north of England, also in Derbyshire, Wales, and Gloucestershire.

Observations.—It is said to occur sometimes in clay-slate, and also in the coal formation. If this statement be correct, then probably the coal formation, red sandstone, and this limestone, belong to the transition class.

II. *Second Secondary Limestone.*—Jameson.

Erster Flœtz Kalkstein.—*Werner?*

Magnesian limestone of English geologists.

Characters.—The colours of this limestone are yellow, and sometimes brown and grey. It is generally small granular, and glimmering or glistering. One variety is flexible. It contains about 20 per cent. of carbonate of magnesia. Its surface is, in many places, covered with a poor herbage, uncommon in limestone, which is said to be owing to the magnesia, which is known to be unfavourable to vegetation.

Petrifactions.—Organic remains are found in it, such as madreporites, encrinites, producti, and fishes.

Geognostic Position.—It rests upon the coal formation, and sometimes alternates with new red sandstone, and with a breccia composed of angular portions of sandstone and limestone, cemented by magnesian limestone. When it comes in contact with coal it deteriorates it. It frequently contains imbedded balls of fœtid limestone, from the size of a pea to two feet in diameter, and which have a stellular radiated structure. The limestone, containing these balls, is generally soft, marly, and magnesian, although the balls themselves contain no magnesia. It forms hills in some places 600 feet high.

Geographic Situation.—It abounds in some districts in England; thus it extends from Sunderland to Nottingham; the coal formation near Whitehaven lies under it, and the same is the case in Derbyshire.

III. *Third Secondary Limestone.*—Jameson.

Muschel Kalkstein.—*Werner ?*
Oolite *of Buckland*,
Lias and Oolite *of others*.

Geognostic Situation.—This formation, according to Mr. Buckland, is divided into the following principal members: viz. *Lower oolite*, including the *Lias limestone*. 2. *Middle oolite*. 3. *Upper oolite*. The first or lower oolite rests upon the variegated or new red sandstone, and the upper oolite lies immediately under the third sandstone-formation. The following is Mr. Buckland's account of this formation.

1. *Lower oolite.*—The lowest member of this portion of the series, or that which rests upon the new red sandstone, is the *lias*, which is a blue, grey, or white argillaceous limestone, disposed in thin beds, in a bluish-grey slaty marl, or clay. It rarely contains chert, more frequently various petrifactions, such as ammonites, pentacrinites, plagiostomites, ostracites, and occasionally remains of crocodiles, as near Lyme, in Dorsetshire.

Geographic Situation.—It extends from a little to the west of Ilchester, in Somersetshire, by Bath and Gloucester, nearly through the centre of England, and terminates a little beyond Lincoln. A few miles beyond Gloucester, it rises to the height of 1124 feet above the sea.

Above the *lias* is the *sand of the inferior oolite*, which is thus described by Buckland:

Sand of inferior oolite	Fine grained yellow, micaceous, loamy sand.
	Green and yellow calcareo-siliceous sandstone, highly micaceous.
	Green and yellow sandy marl, abounding in large concretions, called sand bats.

It occurs in Gloucestershire, Somersetshire, and Oxfordshire.

Above this sand, sandstone and marl is the *inferior* or *bastard oolite*, described as a coarse calcareous freestone, granular, with shelly fragments, and usually ferruginous. It occurs around Grantham, and in other parts of England.

The inferior or bastard oolite is immediately covered by *fuller's earth*, which forms the uppermost layer of the lower oolite. This fuller's earth occurs in layers in a grey-coloured clay, in the middle region of hills around Bath.

2. *Middle Oolite.*—The lowest member of this series is named *Great Oolite*, or Ketton stone, and is described as a durable yellow freestone, composed of oolitic concretions and shelly fragments, united by a calcareous cement. It occurs at Ketton in Northamptonshire, and Windrush in Oxfordshire. Resting on it is the next member of the series, named *Stonesfield Slate*, which is a calcareo-siliceous oolite, sometimes passing into sand, and associated with thin beds of bad coal. The coal of Cleveland Hills, in Yorkshire, belongs to this slate. Above the Stonefield slate is the *Forest marble*, which is a coarse slaty limestone, full of large fragments of shells (Yeovil marble,) and met with near Bath, and in Dorsetshire. The *Cornbrash* rock lies upon the Forest marble, and is a soft, earthy, yellow limestone, of blue and sandy, and occurs in Oxfordshire, and in Wiltshire. Resting on the Corn-brash is the *Kelloway rock*, which is a coarse sandy limestone, with many peculiar ammonites, and other shells, found at Kelloway Bridge, near Calne, in Wilts. A thick deposit of clay, named *Oxford*, *Forest*, or *Fen Clay*, is the next member of the series. The clay is of a bluish-grey colour, and includes hard and large septaria. It occurs in the vale of Thames, from Oxford upwards; vale of Ouse, from Bedford downwards; and the vale of Blackmoor, Dorset.

3. *Upper Oolite.*—The lowest member of this series, or that next in succession to the uppermost of the middle oolite, is a *calcareous grit or sandstone*. It is a siliceous sand and sandstone, with calcareous cement, often shelly, and is met with at Filey, near Scarborough, in Yorkshire, and near Abingdon in Berks. The next member in the series is *Coral rag*, which is a loose earthy oolite limestone, full of coraline remains, and found at Kiddington, near Oxford; at Highworth and Calne, Wilts; and Kirkby Moorside, Yorkshire. *Oxford oolite* is the next rock of the series. It is a perishable freestone, composed of oolitic concretions and shelly fragments united by a calcareous cement. It occurs at Heddington in Oxfordshire; Calne, Wilts; and New Malton, Yorkshire. *Kimmeridge clay* is the rock next in succession. It is a blue slaty clay, with selenite, and is sometimes highly bituminous: Occurs at the base of Shotover Hill, near Oxford; in the island of Portland; and at Kimmeridge, in isle of Purbeck, Dorset. Above the Kimmeridge clay is the *Portland stone*, which is a calcareo-siliceous durable freestone, often oolitic, containing beds and nodules of chert. It occurs in the isles of Purbeck and Portland; Chilmark, Wilts; Twindon; Aylesbury. The uppermost rocks of the series are the *Purbeck beds*. These are strata of slaty clay and marl, alternating with beds of coarse shelly limestone. They occur at Sandwich, Lulworth Cove, and Upway, Dorset; Lady Down, near Tisbury, Wilts.

IV. *Fourth Secondary Limestone, or Chalk.*

Kreide-Gebirge.—*Werner.*
Formation crayeuse.—*Daubuisson.*

This formation consists of three members, viz. *chalk marl*, *hard chalk*, and *soft chalk*.

1. *Chalk marl.*—This is an argillaceous grey-coloured chalk, without flints or chert, passing into a fine micaceous grey sand, or into a grey marl or clay. It rests upon the third sandstone formation, which therefore separates it from the oolite formation. It occurs at

Benson in Oxfordshire; Cherhill and Norton, Bevant, Wilts; Lewes; Guilford; Folkstone; Byarsh near Wrotham, Kent.

2. *Hard Chalk, or Lower Chalk.*—This chalk is harder than that which forms the upper part of the formation, and is sometimes of a brick-red colour. It contains few flints or petrifactions. It occurs near Warminster, Shakespeare's Cliff, Dover; Flamborough Head, Yorkshire; county of Antrim, Ireland. The red varieties occur in Lincolnshire and Yorkshire.

3. *Soft Chalk, or Upper Chalk,*—This is the common chalk of mineralogists, which is soft enough to mark with. It contains abundance of flint, in the form of tuberose, roundish, and ovoidal masses, either irregularly distributed in the mass, or disposed in horizontal layers; the flint is sometimes also arranged in beds, which occasionally extend, without interruption, for more than a mile; and, in other cases, veins of flint traverse the chalk in all directions. The flinty masses are sometimes hollow in the centre, and the walls of the cavities lined with crystals of common quartz. The petrifactions found in the chalk and flint are belemnites, echinites, alcyonites, spongites, ostracites, pectinites, terebratulites, ammonites, plagiostomites, milleporites, &c.; also teeth and palates of fishes of the shark tribe. At the hill of St. Pierre, near to Maëstrich, the remains of a species of *monitor* have been found in a kind of chalk.

Both the hard and soft chalks occur stratified: the strata are generally horizontal; sometimes inclined at a considerable angle, or even perpendicular; and there are instances, as in the Isle of Wight, of perpendicular strata meeting with horizontal, and also of horizontal, or slightly inclined strata resting on vertical strata. Metalliferous minerals occur rarely in this formation, and almost the only species hitherto met with is iron pyrites, which is sparingly disseminated through the chalk.

Geognostic situation.—It rests upon the third sandstone formation.

Geographic situation.—Chalk does not occur any where in Scotland, but in England it forms extensive tracts of country, and has been traced from near Sidmouth in Devonshire to Filey Bay in Yorkshire. It also occurs in Ireland, as in the county of Antrim. Chalk forms a considerable portion of the north of France; it also occurs on the shores of the Baltic, in the Danish islands, in Holstein, Mecklenburg, and Pomerania; it constitutes the principal rock formation in Poland and in southern Russia; and has been found in the Crimea. The following are descriptions of some chalk districts in England, as given by Mr. Phillips from the *Geological Transactions.*

"The chalk cliffs between Deal and Folkstone are extremely interesting. A short distance on the west of Deal, the chalk, with numerous flints, rises from beneath alluvial sand, and continues to rise, constituting the whole cliff for about five miles; namely, as far as St. Margaret's Bay, where the summit is about 150 feet above the sea. West of that place its rise is gradual as far as the cliff above which Dover Castle stands; and the greater part of it, beneath the castle, consists of the chalk with numerous flints; but the lower part of the bed is full of organic remains; of sponges and echinites, &c. of which the traces are visible on the surface of the cliff, projecting from it in the form of knobs, of a colour somewhat darker than the chalk itself. The beds of flint between Deal and St. Margaret's Bay are numerous and thin; but between the latter place and Dover they increase in thickness; and the flints are not nodular, but form beds of irregular thickness, with occasional cavities. The lower part of the cliff, beneath the castle, consists of *chalk with few flints*, in which lie some beds of soft chalk-marl, which, as it falls away by exposure, leaves crevices, by which the stratification is easily traced. These crevices rise from the beach, mid-way between St. Margaret's and Dover, are visible beneath the castle about one-third of the way up the cliff: are again seen in the cliff at the back of the town at a higher elevation, and again near the summit of Shakespeare's cliff on the west of Dover: proving the regular stratification of the chalk, and its gentle dip The low cliff commencing on the west of Dover, consists of a stratum of chalk, containing numerous beds of sponges, and other organic remains, but no flints; this bed forms the great body of Shakespeare's cliff, from the base, to where it underlies the chalk with few flints near the summit, and continues to rise five miles westward, until, near Folkstone, where the cliff is 550 feet high, it forms the greater part of the upper half. Immediately at the foot of Shakespeare's cliff, a new stratum rises from the beach, consisting of chalk, also without flints, containing few organic remains, and above 50 feet thick; it is separated from the superincumbent bed by a bed of marl, which may be seen with little interruption for five miles. A little on the west of Shakespeare's cliff, the *grey chalk* rises, and may be traced to where the high cliff terminates above Folkstone. This chalk is of a grey colour, is softer than common chalk, contains some alumina, and the same kind of organic remains as are commonly found in chalk, and some thin beds of sandstone, but no flints. But it is impossible to discover the thickness of this body, for though the cliff near Folkstone is 550 feet high, a most enormous and picturesque ruin covers its base. It is, however, probable that the chalk there rests upon a bed of blue marl, and that the giving way of this stratum has been the cause of the ruin. The marl is seen lying on the green sand at Copt Point near Folkstone, and at places between that point and the chalk-hills. In the cliffs east and west of Dover, therefore, we have all the members of the chalk formation, except the marls; which, in the Isle of Wight, lie above and below the chalk properly so called."

The chalk of Cambridgeshire is described as consisting of two varieties; the *upper*, containing the common black flint in abundance, and the *lower* or *grey chalk*, which contain little or none. If a line be drawn from Royston by Balsham to Newmarket, it will pretty exactly define the limits of both varieties; the hills to the eastward of it being composed of the upper beds, while those to the west consist of the lower or grey chalk, which composes by far the greatest part of the hills of Cambridgeshire. It is considerably harder than common chalk, and its colour is usually some shade of grey. Its provincial name is *clunch*, and it yields the best lime. Some of the beds are hard enough to serve the purpose of building stone. It also endures the fire well; and is used, like that of Ryegate and Measham in Surrey, for the backs of grates. In the northern extremity of the Cambridgeshire hills, the chalk appears to rest upon an extensive bed of blue clay, termed *gault;* but there is no decisive line of separation between them; they are considered to pass into each other by degrees, the lower beds of the grey chalk becoming more sandy, and assuming gradually the nature of an argillaceous loam

In the wolds of Lincolnshire, the chalk has two colours, red and white, each lying in regular strata, the red being generally undermost; in the white, seams of flint are frequently met with from two to six inches thick. The chalk rests upon a coarse brown pebbly-sand, without organic remains, consisting of quartz and oxide of iron.

V. *Fifth Secondary Limestone.*

This formation is one of the members of the series above chalk, and will be included in the description of the Paris formation.

III. *Secondary Gypsum.*

Flœtz Gyps.—*Werner.*
Secondary Gypsum.—*Jameson.*

There are two principal formations of this rock; one is associated with the rocks of the variegated or new red sandstone, and the other is a member of the series above chalk, or what is called the Paris formation.

1. *First Secondary Gypsum, including Salt.*

Erster und Zweiter Flœtz Gyps, and Steinsalzgebirge. *Werner.*

Characters.—It occurs granular, foliated, fibrous, compact, in crystals (selenite,) and sometimes anhydrous. Its principal colours are white and grey, seldom red or brownish. It occasionally contains imbedded crystals of different kinds, such as quartz, boracite, arragonite, and sulphur; and sometimes disseminated, and imbedded masses of clay, marl, sandstone, limestone, sulphur, and salt.

Subordinate beds.—It contains beds of marl, clay, limestone, sandstone, sulphur, and salt. These beds of salt afford the mineral salt of commerce, and are worked in the salt mines of Cheshire, Austria, and Poland.

Structure.—It is either distinctly stratified, or is disposed in short but thick and unstratified beds. Caves, varying in magnitude from a few yards to many fathoms in extent, occur in it; and of these there are striking examples in Thuringia, and in other countries. It is conjectured that they owe their origin to masses of salt which they formerly contained, and which have been removed in the course of ages by the action of subterranean waters. The magnitude of these caves is further increased by the action of percolating water traversing the gypsum itself. Frequently the roofs of the caves yield and fall in, and thus hollows, often funnel-shaped, are formed in the surface of the country.

Petrifactions.—It rarely contains petrifactions; and of these, species of the following genera have been met with: viz. madreporites, ammonites, tellenites, and branches and trunks of trees variously bituminized.

Geognostic Situation.—It is contained in, or rests upon the new red or variegated sandstone.

Geographic Situation.—It occurs but in small quantities in Scotland, whereas in England it is abundant in some districts, as in Cheshire, Worcestershire, &c.

2. *Second Secondary Gypsum.*

This formation occurs along with the rocks of the Paris formation, and will be described under that head.

IV. *Secondary or Flœtz Trap-Rocks.*

Under this division we include, as a matter of convenience, the secondary trap and porphyries. We shall first describe the traps, and next the porphyries.

Flœtz Trap.—*Werner.*

The rocks of this series are compounds of augite and felspar, with occasional intermixtures of hornblende. The following are the different kinds of these rocks, viz. 1. Greenstone; 2. Amygdaloid; 3. Wacke; 4. Basalt; and 5. Trap tuff.

1. Greenstone.—*Jameson.*
Grünstein.—*Werner.*

Composition.—Is a granular aggregate rock of augite and felspar. The felspar is sometimes red, but more frequently of grey colour, and the augite is almost always blackish-green. It varies from rather coarse granular to the compact, when the concretions are only discernible by means of their glimmering, and then the mass has much of the basaltic character.

Imbedded Minerals.—These are augite, basaltic hornblende, felspar, calcareous spar, diallage, and iron pyrites. In the true porphyritic greenstone, as that of Arthur Seat, the imbedded crystals are of felspar.

Structure.—It is sometimes amygdaloidal, and the amygdaloidal portions are of zeolite, calcareous spar, or quartz. Frequently it is disposed in columns or pillars, and these are again composed of globular and concentric lamellar concretions. Sometimes the whole mass of the bed is arranged into balls or globular concretions, or is disposed in tabular concretions. The beds vary in thickness from a few inches to many fathoms, and in the thicker beds stratification is discernible.

Cotemporaneous Veins.—Very often beds of secondary greenstone include veins of various descriptions, that appear to be of cotemporaneous formation with the rock. The following enumeration contains a few of the veins met with in the secondary greenstones of Scotland:

1. Calcareous spar. 2. Calcareous spar and quartz; the quartz sometimes in the form of amethyst or rock-crystal, but more frequently as common quartz. 3. Calcareous spar, common quartz, and calcedony. 4. Calcareous spar, heavy spar, and quartz. 5. Calcareous spar, and heavy spar, with glance coal. 6. Calcareous spar, heavy spar, and brown hematite. 7. Quartz, with red hematite and iron glance. 8. Calcareous spar, brown spar, and sparry iron. 9. Calcareous spar, heavy spar, prehnite, and zeolite. 10. Felspar, either grey or red. 11. Iron pyrites. 12. Red cobalt. 13. Yellow copper pyrites.

Petrifactions.—Fossil organic remains are of rare occurrence in trap rocks. Petrified shells have been found in greenstone, and also in that slaty rock (slaty compact felspar) frequently associated with it.

Geognostic Situation.—Occurs in beds, imbedded masses, and veins, in the old red sandstone, coal formation, variegated sandstone, and in various secondary limestones. Veins occur in primitive and transition districts. It is occasionally associated with a *secondary sienite.*

Geographic Situation.—It is a very abundant rock in the sandstone and coal districts of Scotland, and is not unfrequent in many primitive and transition tracts also in this country. Veins of it traverse the coal formations in the north of England, and although met with in other parts of England, is by no means so abundant there as in Scotland.

2. Amygdaloid.—*Jameson.*
Mandelstein.—*Werner.*

Characters.—This rock has a basis or ground including amygdaloidal portions of various minerals. The basis or ground is generally an intimate combination of augite and felspar in a very imperfectly crystallized state. Its colour is frequently green; sometimes reddish when much iron-shot; or nearly black when the predominating material is augite. The amygdaloidal masses vary in their nature; some are calcareous spar, or brown spar, or heavy spar, while others are green earth, quartz, steatite, or lithomarge.

Imbedded Minerals.—Besides amygdaloidal masses, the rock sometimes contains crystals of felspar, augite, or hornblende, thus affording examples of the union of the amygdaloidal and porphyritic structures.

Structure.—It occurs in columnar, globular, and also in tabular distinct concretions; and occasionally it is imperfectly stratified.

Geognostic Situation.—It generally occurs in mountain masses or beds, and sometimes in veins, and principally associated with rocks of the sandstone and limestone series.

Geographic Situation.—It is an abundant rock in the south and middle divisions of Scotland, both on the mainland and among the islands, as in Arran, Mull, Rum, Eigg, Canna, and Skye.

3. Wacke.—*Jameson.*
Wacke.—*Werner.*

Characters.—This rock has generally a greenish-grey colour; less frequently it is reddish, or of a brown or blackish cast. The fracture surface is dull, or only faintly glimmering, and the fracture is even, or flat conchoidal. It is opaque, and more or less shining in the streak; soft; sectile; easily frangible; and specific gravity about 2.8.

Composition.—It appears to be a very intimate combination of earthy augite and earthy felspar.

Structure.—Sometimes occurs in globular and imperfect columnar concretions, and occasionally it has the amygdaloidal structure.

Geognostic Situation.—It occurs in beds, imbedded masses, and in veins in sandstone and limestone.

Geographic Situation.—It occurs along with amygdaloid and greenstone in our coal-fields in different parts of Scotland, and also in the new red sandstone, and some other secondary formations.

4. Basalt, *Jameson.*
Basalt, *Werner.*

Characters.—Its colours are generally greyish, or greenish-black, and rarely inclines to grey. Internally it is dull or feebly glimmering. The fracture in the coarser varieties is large, or small-grained uneven; of the more crystalline varieties, even inclining to large and flat conchoidal, and seldom to splintery. It is opaque, or feebly translucent on the edges. It yields a pale grey-coloured streak. It is semi-hard, bordering on hard. It is rather brittle, and is difficultly frangible. Specific gravity = 3.08.

Structure.—It occurs in distinct concretions of various descriptions. They are generally columnar, varying from a few inches to some fathoms, even to upwards of 100 feet in length; the number of sides varies from three to nine, and of these the nine-sided are the rarest; they are straight, curved, and either parallel or diverging; sometimes they are articulated, and the joints have concave and convex faces. In mountains, these concretions are collected into large groups, and many of these groups or colossal concretions form a hill or mountain. Sometimes it occurs in tabular, sometimes in globular concretions; these latter are frequently composed of concentric lamellar concretions, or of columnar concretions radiating from a centre. Some varieties are composed of large, coarse, and fine granular concretions.

There is sometimes a tendency to stratification, and varieties occur with the amygdaloidal, and also with the porphyritic structures.

Imbedded Minerals.—The most frequent imbedded minerals are olivine and augite; besides these, grains and crystals of felspar, and also of basaltic hornblende, calcareous spar, and magnetic iron ore, are met with.

Decomposition.—Some varieties are easily decomposed, particularly those that incline to wacke and amygdaloid, while others long resist the action of the atmosphere. The earth formed by their decomposition has a greasy feel, and the great fruitfulness of basalt countries is owing to this basaltic earth. Sometimes the imbedded minerals decompose, at length fall out, and thus leave the basalt with a vesicular structure. Olivine is one of the most easily decomposable of the simple minerals met with in basalt, being even more easily broken down by the influence of the weather than calcareous spar; on the contrary, we often find augite and hornblende unchanged, after the basalt has been reduced to a clayey mass.

Forms.—It occurs frequently in the form of mountain caps, having tabular or conical forms; or it is distributed in long ridges, or in scalarlike cliffs and terraces.

Geognostic and Geographic Situations.—It occurs in beds, imbedded masses, and veins, in sandstone and limestone formations in Scotland, England, and Ireland.

5. Trap-tuff, *Jameson.*
Trap-tuff, *Werner.*

Composition.—This rock has a conglomerated structure, and therefore has a basis or ground, with imbedded masses of various forms and sizes. The ground or basis varies in its nature; sometimes it is wacke or greenstone, or it inclines to basalt or amygdaloid. The imbedded masses, which are of various roundish and indeterminate angular forms, are of wacke, amygdaloid, greenstone, and basalt; and intermixed with these are sometimes masses of sandstone, limestone, slate clay, bituminous shale, and jasper. The masses vary in size, from that of a pea, to several yards, or even fathoms, in length, breadth, and thickness.

Petrifactions.—It sometimes contains trunks and branches of trees, more or less bituminized.

Structure.—It occurs in beds, which are from a few inches to many fathoms in thickness; is sometimes distinctly stratified, and occasionally it is disposed in globular distinct concretions, the balls varying from a few inches to several feet in diameter, and also in columnar concretions.

Geognostic Situation.—It occurs in imbedded masses, beds and veins, along with the other rocks of the secondary trap series already enumerated.

Geographic Situation.—A considerable portion of Arthur Seat is composed of this rock; it abounds in many of our red sandstone and coal districts, and is very frequently met with among the Hebrides, as in Canna and Eigg.

B. Secondary Porphyry, *Jameson.*
Flœtz Porphir, *German Mineralogists.*

The secondary porphyries are composed of felspar in various states of aggregation, hornstone, and pitchstone, with intermixed grains and crystals of felspar, quartz, and other minerals.

The following are the rocks, arranged under this head:

1. Claystone. 2. Claystone porphyry. 3. Felspar. 4. Felspar porphyry. 5. Clinkstone. 6. Hornstone porphyry. 7. Pitchstone. 8. Pitchstone porphyry.

1. Claystone, *Jameson.*
Thonstein, *Werner.*

This rock, which is described in p. 462, appears to be felspar in a comparatively loose state of aggregation. It is sometimes conglomerated, and then is named claystone tuff. It is disposed in beds and veins in sandstone districts, and in coal-fields, both in England and Scotland. It is always an accompanier of rocks of the secondary porphyry formation.

2. Claystone Porphyry. *Jameson.*
Thonstein Porphir, *Werner.*

Composition.—This porphyry, as its name intimates, has a basis of claystone, in which imbedded crystals of felspar are contained.

Structure.—It occurs in columnar, tabellar, and globular distinct concretions; is sometimes conglomerated, rarely vesicular, and occasionally imperfectly stratified.

Imbedded Minerals.—These are felspar, quartz, either in grains or in double six-sided pyramids, mica, augite, hornblende, and iron pyrites.

Petrifactions.—Trunks, branches, and twigs of trees, occur imbedded in this rock, and these are generally penetrated or petrified with wood-stone.

Geognostic Situation.—It occurs in imbedded masses, beds and veins, in secondary sandstone and limestone districts, and is sometimes associated with the secondary trap-rocks.

Geographic Situation.—The Pentland and Ochil hills, near Edinburgh, contain abundance of secondary porphyry, and the same is the case in some districts in the south and north of Scotland, and also in England and Ireland. It is a frequent rock in similar situations on the continent of Europe.

3. Felspar, *Jameson.*

This mineral occurs as a mountain rock, with red or grey colours, and either very minutely foliated, or in a compact state.

Geognostic and Geographic Situations.—It occurs along with porphyry and claystone, in the Pentlands and Ochils; also in Arran, and in several places on the east coast of Scotland, associated with old red sandstone.

4. Felspar Porphyry, *Jameson.*
Felspath Porphir, *Werner.*

This rock differs from the preceding, in always containing imbedded grains and crystals of felspar.

Geognostic and Geographic Situations.—It occurs along with clay-stone porphyry, and other rocks of this series, in the Pentlands and Ochils, and in other parts of Scotland.

5. Clinkstone Porphyry, or Porphyry-slate, *Jameson.*
Klingstein Porphir, *Werner.*
Phonolith, *Daubuisson.*

This rock has a basis of that kind of felspar named clinkstone, with imbedded crystals of felspar, whence it is named clinkstone-porphyry, or porphyry-slate, from its slaty structure. The colour of the basis is greenish, yellowish, smoke, bluish, or ash-grey; sometimes, also, blackish-green; and when much impregnated with iron, liver-brown and reddish-brown. Sometimes several colours occur in the same mass, and it is occasionally marked with greyish-coloured spots, and frequently shows dendritic delineations on its surface. Its fracture is splintery in the small, but slaty in the large. Hardness same as that of felspar. It is more or less translucent on the edges, and some varieties are opaque.

Imbedded Minerals.—Besides the imbedded grains and crystals of felspar, it also occasionally contains crystals of augite and basaltic hornblende, zeolite in drusy cavities, and very seldom quartz, calcareous spar, iron-pyrites, and iron-sand. It is sometimes vesicular.

Structure.—It is frequently arranged in columns and tables, like those of basalt.

Decomposition.—It long resists the action of the weather, but in course of time it becomes covered with a thin crust, which has usually a greyish white colour in the pure, but of a reddish colour in the iron-shot varieties.

Forms.—Like basalt, it frequently forms conical and tabular hills, and exhibits numerous striking and rugged cliffs.

Geognostic Situation.—It occurs in imbedded masses, beds, and veins, in red sandstone, in the coal-formation, and also in secondary limestone.

Geographic Situation.—It is a frequent rock in the islands of Arran and Lamlash in the Frith of Clyde; is met with in the Girleton hills near Haddington, North-Berwick Law, Traprain Law, and Braid Hills, near Edinburgh.

6. *Hornstone Porphyry.*

Hornstein Porphir.—*Werner.*

This porphyry occurs in imbedded masses, beds, and veins, along with clay-stone porphyry, and in similar situations, both geognostically and geographically.

7. *Pitchstone.*

Pechstein.—*Werner.*

This rock, of which a description is given in the oryctognostic part of this article, occurs in considerable abundance in the form of beds and veins in red sandstone, in Arran, and other districts in Scotland.

8. *Pitchstone Porphyry.*

Pechstein Porphir.—*Werner.*

This rock, which has a base or ground of green or black pitchstone, always contains imbedded grains and crystals of felspar, which is generally the glassy kind.

Structure.—It occurs in globular, columnar, and tabular concretions.

Imbedded Minerals.—Besides felspar, it sometimes contains imbedded calcedony, common quartz, calcareous spar, and also zeolite.

Geognostic Situation.—It occurs in beds, imbedded masses and veins, in various secondary trap rocks, also in red sandstone, and in secondary limestone.

Geographic Situations.—It abounds in the island of Arran, occurs also in Lamlash, and is met with in Mull, Eigg, Sky, and other parts of Scotland.

V. *Formations above Chalk, or Paris Formation.*

Terrain Tertiaires.—*Daubuisson.*

Under this division, we include all the different secondary beds which are of posterior formation to chalk. They are principally marl, clay, and sand, interstratified with beds of limestone, sandstone, and gypsum. The only metalliferous minerals they contain are, iron pyrites, and brown ironstone, but many of them abound in organic remains. This set of rocks appears more of a local nature than any of those hitherto described. The following description is illustrative of this formation, as it occurs around Paris.

Geographic Distribution.—It extends all around Paris; to the north, as far as Senlis and Laon; to the east, to Rheims and Epernay; to the south, to Orleans; and to the west, to Chartres and Mantes. It may be considered as composed of seven systems of beds, viz.

1. Plastic clay with sand.
2. Coarse limestone, or limestone with cerites, and accompanying sand and sandstone.
3. Siliceous limestone.
4. Gypsum and marl.
5. Marl.
6. Sand and Sandstone.
7. Fresh-water limestone and mill-stone or buhr-stone,

The chalk on which they rest presents numerous inequalities, in and over which these beds are arranged, and generally in a horizontal or slightly inclined position.

1. *Plastic Clay and Sand.*

This bed, which rests immediately upon the chalk, consists of an unctuous, tenacious, and variously coloured clay, employed by potters, and named by Brongniart, plastic clay. It contains little chalk, but is frequently intermixed with sand, particularly towards its upper part; sometimes this sand is divided into two beds. It varies in thickness, in some points not exceeding a few inches, in others being many fathoms. It contains few shells, and these are marine.

2. *Coarse Limestone, with Sand and Sandstone.*

Above this clay is a bed principally of a calcareous nature, composed of an alternation of beds of coarse limestone, marl, and slate-clay, which occur always in the same order, over an extent of 25 leagues of country. The average thickness of the whole together is about 90 feet.

The lower beds are very sandy, and often contain grains of a green matter, resembling that found in the *green sand*, already described as lying under the chalk formation, and abounds on marine shells.

In the superior beds, there are layers several feet thick, of a pale-yellow limestone, which is pretty hard, and in large grains, and forms the principal building-stone at Paris. They contain great abundance of petrifactions, and particularly of cerites, and are covered by marly beds. Siliceous productions occur principally towards the upper part of the formation, and these are flint, or flint passing to hornstone, and crystals of quartz. In some places the siliceous matter occurs in considerable masses, even whole beds, sometimes in the form of sandstone, which abound in marine shells, and occasionally also contains fresh-water shells, such as lymnæa and cyclostomæ.

3. *Siliceous Limestone.*

Above the coarse limestone is a limestone which contains fresh-water shells. It is stratified, and the strata are sometimes soft and white, sometimes grey and compact, and penetrated with silica, in all directions. Sometimes the walls of cavities and fissures are lined with calcedony and small crystals of quartz; in other instances the siliceous matter is formed into masses of vesicular and corroded quartz, named *buhr* or *millstone*, which has been regarded as the skeleton body of a siliceous limestone, the calcareous portion of which has been removed.

4. *Gypsum.*

The gypsum formation rests on the beds just described. It consists of an alternation of beds of gypsum and marl. Where thickest, as at Montmartre, near Paris, it is divided into three beds. The *lowest bed* is composed of thin layers of gypsum, which is often lamellar, of solid calcareous marl, and slaty argillaceous marl, in which menilite is found; and the under part of this bed sometimes encloses marine shells. In the *second bed*, the gypsum is in great quantity, but the marl in small quantity; no shells occur, but petrified fishes are met with. The *uppermost bed*, which is the principal one, is four times thicker than the others, and is that which is quarried on account of its gypsum; thin beds of marl occur; the gypsum is sometimes 60 feet thick; it is naturally divided into large irregular prisms like basalt; it is pure, and is granular foliated; the lower part often contains flint, and the superior part passes into marl. This bed is particularly distinguished by the multitude of bones, particularly of quadrupeds, which it contains; and it also contains some fresh water shells. This formation, at its line of junction with the rock of limestone, on which it rests, is intermixed with and passes into it.

5. *Marl.*

The marls that rest upon the gypsum, and which often replace it, are of two kinds; one is of the same nature as that which alternates with the gypsum, and contains fresh water shells, while the other contains marine shells.

The first are in general white and calcareous; they contain silicified trunks of the palm tree, and species of lymneus and planorbis. Above these are beds of argillaceous marl, which are sometimes 60 feet thick. In these beds, balls of celestine or sulphat of strontites occur. It is succeeded by several thin beds, and the whole is terminated by two beds, containing vast abundance of oysters.

6. *Sand and Sandstone.*

Resting upon the marls when the succession of beds is complete, there is a great bed composed of sand and sandstone, sometimes 300 feet thick.

The sand consists of angular particles of quartz, mixed with earthy carbonate of lime, and fragments of shells; sometimes it is quite pure and thin; it is used for making plate glass. There arises from amongst this sand a kind of sandstone, which is used in paving the streets of Paris, and the roads in its vicinity. It is composed of transparent shining angular particles of rock-crystal immediately connected together, or without any basis or cement. Sometimes the particles are so loosely aggregated, that they can be separated by the simple pressure of the finger, while in other cases they are so closely aggregated as to pass into a state nearly approaching to that of compact quartz. The sandstone or quartz is disposed in the sand in various ways; sometimes it is in large or small imbedded masses, or in beds sometimes several feet thick, and extending to a considerable distance. This bed of sand and sandstone, contains few marine organic remains, and those that do occur are confined to its upper part, where it is intermixed with a calcareous sand. It is indeed a general observation, that animal remains occur very rarely in quartzy rocks, but abundantly in those of a calcareous nature.

Sometimes the sandstone contains cotemporaneous portions of flint, hornstone, flinty-slate, and thus a conglomerate is formed.

7. *Fresh Water Limestone, with Millstone, or Buhrstone.*

There frequently rests immediately upon the preceding sand and sandstone, a thick bed consisting of layers of sand, marl, clay, and millstone. The mill or buhrstone is quartz, in a vesicular and corroded form, and which forms beds sometimes upwards of one hundred feet thick. Its vesicular form adapts it for millstones, and hence it is very extensively quarried for this purpose, and exported to England and other countries.

Above these layers, and forming the uppermost portion of the series of rocks which rests upon chalk, is a formation of limestone different from those already described, and which extends to very considerable distances. It is highly impregnated with quartzose matter, and contains abundance of fossil shells, which are said to belong to the division of *land and fresh water shells*, and hence this limestone has been named *fresh water limestone*. It is of a yellowish white colour, fracture earthy or conchoidal, varies in hardness from that of compact limestone to that of the softer marls. It frequently contains flint and hornstone, and also beds of the vesicular quartz, or buhrstone, which, in general, is more compact than that found in the preceding formation. It is further particularly distinguished by its containing numerous irregular cylindrical cavities, and by the animal remains it contains, resembling, in characters, the genera lymnæa, planorbis, cyclostoma, and helix of our present marshes.

Observations on the Paris Formation.

This remarkable group of rocks has been sometimes distinguished into four divisions or beds, according to the kind and distribution of the organic remains it contains. The *first* or *lowest bed* includes the plastic clay, coarse limestone and inferior sandstone, in all of which the organic remains are said to be entirely *marine*. The *second bed* contains the lower siliceous limestone, and the lower gypsum and marls, both of which contain scarcely any other petrifactions than those of land and fresh water animals; and hence is called a *fresh water formation*. The *third bed* is composed of the superior marls, sands, and sandstones, and the few petrifactions it contains are of *marine shells*. Lastly, the *fourth bed* is a great *fresh water formation*.

A series of rocks, possessing many of the characters of those around Paris, occurs in the Isle of Wight, and the neighbouring districts in the south of England, and has been well described and illustrated by an excellent man and good observer, Mr. Webster of the Geological Society of London. Beudant describes rocks of the same nature as occurring in Provence, and informs us that the famous quarries of Aix, which afford so many different kinds of petrified fishes, are situated in a marl belonging to the Paris formation. The famous district of Oeningen on the banks of the Lake of Constance, so well known to naturalists on account of the great variety of petrifactions it affords, agrees in its general characters with the Paris formation. The fresh water limestone has been found in Auvergne, in the vicinity of Montpellier, to the north of Tarn, between Montauban and Agen; also in Spain, in the vicinity of Burgos and Seville; in Germany, near Ulm; and in Italy, in the Roman States.

8. *Brown-Coal, assosiated with Rocks above Chalk.*

Associated with a group of rocks above chalk, there are sometimes extensive formations of brown-coal. There is a fine example of this arrangement of brown-coal in the North of France, in the country extending from Beauvais to the vicinity of Rheims. There are five beds of brown-coal, varying from two to six feet in thickness; and are separated from each other by layers of gravel and loam. Both the coal and the layers between it are impregnated with iron pyrites. The whole is covered with beds of marl and limestone; those beds which rest immediately upon the coal contain fresh water shells, while those at a distance from it include marine shells; and it is said that the uppermost part is a shelly sandstone. M. Marcel de Serres informs us, that in the vicinity of Beziers fresh water shells are found in a bed of brown-coal, which is covered by bituminous beds, bituminous limestone, with fresh water shells, compact limestone, without shells, and, lastly, with a limestone containing impressions of cerites. Sometimes this brown-coal is covered with trap-rocks or lavas.

The brown-coal formation contains a few imbedded minerals, such as iron-pyrites, bog-iron ore, selenite, honey-stone, retin-asphalt, and a mineral of an inflammable and waxy nature.

Class IV. Alluvial Rocks.

This class comprehends those rocky substances formed from previously existing rocks, of which the materials have been broken down by the agency of water and air; they are therefore generally loose in their texture, and are never covered with any real solid and rocky secondary strata.

Werner divides them in the following manner:

1. *Mountain alluvial formations.*
   - *a*. On the summits of mountains.
   - *b*. On the sides of mountains, and at the foot of mountain ranges.
2. *Alluvial formations of low or flat lands.*

1. Mountain alluvial formations.

a. On Summits of Mountains.

The alluvium found on the tops of mountains, and mountain-chains, consists generally of a thin bed formed by the decomposition of the immediately subjacent rocks. This bed, particularly when covered with vegetable matter, forms a coat which long protects the solid strata from the wasting influence of the weather.

b. In Valleys.

The disintegrated rocks on the sides of valleys, yielding to their own weight, or carried downwards by torrents, are stopped at the foot of the mountain; they are accumulated there, and, in the course of time, form a deep protecting cover for the lower part of the mountain, and fill up the bottoms of the valleys.

c. At the foot of Mountain Ranges.

Besides the alluvial covering on the bottoms of valleys, and on the basis of their bounding hills and mountains, there often occurs very extensive alluvial formations, extending to a greater or lesser distance from the general foot of the acclivity of the great mountain-chains, or mountain groups. These formations are composed of fragments of the neighbouring mountains, but are arranged in a vast horizontal bed; thus intimating that they must have been levelled by the action of a great mass of water, in the form of a lake or inland sea. The plains of Piedmont and Lombardy, at the foot of the Alps, present a colossal example of this kind of alluvial formation.

2. Alluvial formations of the low or flat lands.

The alluvial substances met with in the great plains are principally sands and clays of different descriptions. These occasionally include various minerals, such as calcareous tuffa, peat, &c.

We shall first describe the sand and clays, and afterwards the calcareous tuffa, and other subordinate substances met with in them.

a. Sand.

Sand, as is well known, is formed of small grains supposed to have been derived from previously existing rocks of a quartzy nature. It sometimes covers immense tracts of country, and forms great deserts, as those of Barbary and of Arabia.

The extreme fineness of the particles renders the sand moveable by the slightest breath of wind, so that when the storm rages, the desert presents a picture of moving waves, mountains, and pillars, that baffle all description, and which overwhelm vast tracts of country, carrying every where desolation and destruction.

Downs.—When the sea-coast is low, and the bottom consists of sand, the waves push this sand towards the shore, where, at every reflux of the tide, it becomes partially dried; and the winds, which almost always blow from the sea, drift up some portion of it upon the beach. By this means, *downs*, or ranges of low sand hills, are formed along the coast. These, if not fixed by the growth of suitable plants, either disseminated by nature, or propagated by human industry, would be gradually, but certainly, carried towards the interior, covering up the fertile plains with their sterile particles, and rendering them unfit for the habitation of mankind; because the same winds which carried the loose dry sand from the shore to form downs, would necessarily continue to drift that which is at the summit further towards the land.

b. Clays.

Many extensive plains are covered with clays and loams of various descriptions; these also occur filling up hollows in plains, and forming extensive tracts on the sides of lakes, and at the mouths of rivers where they enter lakes, or meet with the waters of the ocean. These clays are formed by the disintegration of felspar, micaceous, and slate rocks.

1. *Substances that occur in the sand and clay.*

These are, 1. Calcareous tuff; 2. Bog-iron ore; 3. Ores, metals, and gems in grains; 4. Common salt; 5. Subterranean and submarine forests; 6. Peat.

1. *Calcareous tuff.*—There are two kinds of this rock, one of old formation, and another which is daily forming. The first appears to have been deposited from the waters of lakes that formerly existed in limestone districts, but which have long since disappeared. Thuringia affords striking examples of this formation of calc-tuff. The tuff there rests upon gravel, or on the rocks of which the country is composed: it forms beds sometimes upwards of fifty feet thick, and which are composed of strata of compact and porous tuffa, which frequently alternate with each other, and between them are sometimes thin beds of a brown bituminous earth. When the lakes contain no plants, then the tuff deposited in it is always compact, but if, on the contrary, they abound in reeds, rushes, confervæ, &c. the tuff, owing to this intermixture, is porous, and loose in its texture. These tuffs in Germany contain osseous remains of elephants, rhinoceroses, megatheria, deers, &c. and sometimes also remains of fresh water shells, analogous to the species at present met with, and also impressions of indigenous plants; and very lately fossil human skulls are said to have been met with in this formation.

The waters which flow along the surface of the globe, and which are charged with calcareous earth, deposit it on the districts they traverse, and thus form tuffas, which are either porous or compact. An example of this formation occurs at Starlyburn near Burntisland in Fifeshire.

2. *Bog-iron ore.*

Water, in its passage over and through rocks containing iron, abstracts a portion of it; it also carries away the iron contained in the beds of decaying vegetable matter it passes through, and in both cases a portion of the water combines with the iron, so that when the iron comes to be deposited on the bottom of lakes, or spread over the flat country, it appears in the form of hydrate of iron, and thus gives rise to the beds of *bog-iron ore*, met with in alluvial districts. In many districts in Scandinavia, where the primitive strata are very richly impregnated with iron, bog-iron ore is found in great abundance in the bottom of lakes, and so rich as to yield 60 per cent. of hydrate of iron. The iron is dredged out in some instances every ten, in others every twenty and thirty years, thus showing the rapid renewal of the deposite. Some lakes or morasses, the bottoms of which are covered with these ferruginous deposites, dry up, and become covered with a bed of soil and grass, and thus form *meadow-ore*:—Werner gives the following account of the formation of this ore of iron, as observed by him in Lusatia. He distinguishes three principal varieties, which he refers to three periods of formation; that which is obtained from swamps, and which is still soft at the time of its being removed, he names *swamp-ore*; that which is hard and covered with marsh plants, is his *marsh-ore*; and lastly, that which is dug from districts entirely dry and covered with a thin layer of soil, is named *meadow-ore*.

3. *Ores, metals, and gems in grains.*

Some kinds of alluvia, particularly those in mountainous districts, contain masses and grains of ores and native metals, which are derived from metalliferous veins, metalliferous beds, or from rocks through which the metalliferous minerals have been disseminated. If the minerals yield easily to decomposition and trituration, they are reduced to very minute particles, and become intimately mixed with various clays and loams; but if their hardness and tenacity is such that they resist obstinately, then they appear in rolled pieces, and in grains of various sizes and forms. The ores and metals most frequently met with in this situation, are iron-pyrites, tin-ore, native gold, and platina. The three latter are those which, on account of their value, are extracted from the sands and clays by washing.

The washing for gold is practised in many countries, and in some, as in Brazil, to a great extent. Indeed, nearly three-fourths of the gold of commerce are obtained from sand by washing.

Platina is obtained by washing the alluvial soil of the province of Choco in Peru; and there it is accompanied with fragments of basalt, zircon, titanium, iron sand, and grains of gold. The metals known under the names palladium, rhodium, osmium, and iridium, are also obtained from the sands of Choco.

Tin-ore is found in considerable abundance in alluvial soil in Cornwall, Saxony, and in the island of Banca.

Many of the gems are obtained by washing alluvial sands and clays; the pyrope or garnet of Bohemia, zircons, rubies, topazes, and diamonds, are collected in alluvial districts.

4. *Common Salt.*

Rock-salt occurs in great abundance in the deserts of Africa and Arabia, the plains of Persia, and the steppes of Siberia.

5. *Subterranean and Submarine Forests.*

Sometimes whole forests are found covered with alluvial deposites, and these are either under alluvium on the dry land, or extend under the waves of the ocean. The first are denominated subterranean, and the latter submarine forests. There is an extensive subterranean forest in Lincolnshire, and another in Lancashire; and on the coast of Lincolnshire there is an immense submarine forest, which has been particularly described by Mr. Correa. The sinking and sliding of the alluvial strata, and the breaking down of natural sea-barriers on front of flats, marshes, and lakes, easily explain all the phenomena exhibited by submarine forests.

6. *Peat.*

There are six different kinds of peat, viz. *mountain*, *marsh*, *lake*, *forest*, *marine*, and *transported*, all of which we shall describe in our natural and economical history of this substance under the head PEAT.

CLASS V. VOLCANIC ROCKS.

We include under this class all those rocks which are alleged to have been formed by the agency of volcanoes. They may be divided into the following orders. 1. Pseudo-volcanic. 2. Thermal, or those formed from the water of hot springs. 3. Those formed from torrents of hot water issuing from volcanoes. 4. Rocks formed by torrents of mud flowing from subterranean volcanic lakes. 5. Rocks formed by air or mud volcanoes. 6. Volcanic.

1. *Pseudo-volcanic.*—Pseudo-volcanic rocks are portions of previously existing strata, which have been more or less altered by the action of heat emanating from beds of coal in a state of combustion. The following species are enumerated by geologists. 1. *Burnt-clay.* 2. *Porcelain-jasper.* 3. *Earth-slag.* 4. *Columnar clay-iron ore.* And 5. *Polishing-slate.*

1. *Burnt-clay.*—Its colour is usually red, and sometimes grey, yellow, and brown, and occasionally spotted or striped. Sometimes it encloses impressions of plants. It is clay or slate-clay burnt, but not so much changed as to form a porcelanous mass.

2. *Porcelain-jasper.*—It is slate-clay, or common clay, changed into a kind of porcelain by the action of heat. Like the preceding species, it sometimes contains impressions of plants, a fact which shows that it has not been completely melted.

3. *Earth-slag.*—This is clay, or clay iron-stone, converted into a kind of slag. It is black, brownish, or reddish, and it has occasionally a tempered steel tarnish. It is amorphous or vesicular, and has sometimes metallic lustre.

4. *Columnar clay iron-ore.*—This is clay iron-ore, which is supposed to owe its columnar concretionary form to the action of heat.

5. *Polishing-slate*—Is a grey or white coloured thin slaty light mineral, which Werner conjectures to be the ashes of burnt coal, which have been carried by water into low situations, and deposited in a slaty form.

Situation.—Pseudo-volcanoes usually occur in low situations, and sometimes also in hilly country, and always in rocks of the coal formation.

Phenomena.—They are discovered by the heat of the surface of the earth in their vicinity; sometimes by smoke, and more rarely by flames issuing from rents in the ground. Sulphureous and ammoniacal vapours frequently occur, and these, in their course upwards, incrust the fissures of rocks, and even the surface of the ground, with sulphureous and ammoniacal matters.

2. *Thermal-Rocks, or those formed from Water of Hot-Springs.*

Olafsen, Povelsen, Menge, and others, speak of thermal rocks having many of the characters of basalt, porphyry, wacke, &c. which occur in districts where formerly hot-springs existed, and even say they have observed them actually forming around many of the magnified hot-springs at present in a state of activity in Iceland. These thermal trap-rocks, viz. thermal, basalt, wacke, amygdaloid with calcareous spar, porphyry, &c. are alleged to be brought from the interior of the earth, by the water of hot-springs, partly in a state of solution, partly in a state of mud, and are deposited over flat or hilly tracts of country, when they gradually harden, sometimes crystallize, and assume their various permanent characters. The amygdaloidal traps appear to be formed in those cases where carbonate of lime is present; the obsidian where dissolved silica prevails; and in the same general way we might account for the formation of the other rocks.

The hot-springs of Carlsbad in Bohemia are of this description, and the well known hot-springs of San Filippo in Tuscany, have formed a hill of calcareous tuffa, in many places as compact and hard as limestone. The famous rock named *travertino* by the Italians, and which abounds in South-western Italy, is a product partly of hot, partly of cold springs. The ancient temples, and the gorgeous palaces and churches of Rome, and indeed the whole of the streets and squares of the former Mistress of the World, are built of concretionary masses which have been deposited by springs.

There are many considerable hot-springs around Guancavelica in South America, the waters of which spread over the neighbouring country, and deposit upon it an ash-grey or whitish substance, (calc-tuff, sinter and travertine?) which acquires a great degree of hardness. The spring-water is so highly impregnated with the earthy matter, that the inhabitants receive it in square boxes or moulds, which it fills in a few days, and the blocks, thus formed, are used for building. Indeed the greater part of Guancavelica, like Rome, is built of the concretionary rock formed from springs.

3. *Rocks formed from torrents of Hot Water issuing from Volcanoes.*

There are on record authentic instances of torrents of hot water flowing from the crater or the sides of volcanoes, when in a state of activity, which, when collected in hollows, or spread over plains, deposits various earthy matters, which at length assume the character of rocks. In the year 1751, a torrent of salt water burst from Ætna, and continued to flow for a quarter of an hour, and was so considerable that the inhabitants named it *Nilo d' Acqua*. Dolomieu and Hamilton observed traces of a frightful torrent of hot water which had issued from the great crater of Ætna; and Spallanzani is of opinion, that part of the tuffas of Italy have been formed by muddy eruptions. In those volcanic mountains whose summits are above the snow line, as is the case in Iceland and in South America, great floods of hot water, charged with earthy matter, burst from the mountains and devastate the surrounding country. Bouger and Condamine saw dreadful ravages committed by these torrents; and the latter writer informs us, that after an explosion of Cotopaxi, a village situated thirty leagues in a straight line, and probably sixty leagues following the wavings of the ground, was entirely carried away by one of those torrents. These torrents from the ice-capped volcanoes appear to be entirely external, while those first mentioned seem to come from the interior of the volcanoes.

4. *Rocks formed by Torrents of Mud flowing from Subterranean Lakes.*

In the interior of volcanic mountains, there sometimes occur caverns or hollows partly filled with water, thus forming subterranean lakes. The earthquakes that often agitate these mountains, are occasionally so violent as to produce great rents, which give free passage to the water of the lakes, which bursts forth with tremendous violence, deluges the neighbouring country, and covers it to a greater or less extent, and with a more or less deep crust of muddy matter. In the earthquake of the year 1746, which overturned Lima, four volcanoes opened at Lucanas, and in the mountains of Conception, and occasioned frightful deluges. The volcanoes of the kingdom of Quito sometimes exhibit phenomena of the same kind, but accompanied with circumstances so extraordinary that we shall now state them. The enormous volcanic cones of Cotopaxi, Pichincha, Tungouragua, &c. in South America, never throw out lava, but frequently ashes, scoriæ, and pumice, and sometimes vomit forth immense quantities of water and mud. These eruptions take place more frequently from the sides than from the craters of the volcanoes, and the muddy waters appear to be derived from lakes situated in the interior of the mountains, which burst forth with incredible fury, when any accidental cause, such as an earthquake, splits, and thus opens the side of the mountain. In the year 1698, the mountain of Carguarazo, near to Chimboraco, fell down and covered eight square leagues of country with mud. In the earthquake of the fourth February, 1791, 40,000 persons were destroyed by eruptions of water and mud, (moya.) Muddy waters, resembling those which flow from volcanic mountains, are vomited forth in great quantity, from districts where no volcanic rocks occur, when these are agitated by earthquakes or other causes. In Peru and Quito, the devastations occasioned by volcanoes are not caused *by streams of lava*, but by water and *enormous streams of mud*, which, when hardened, is found to contain crystals of felspar, and to resemble porphyry.

5. *Rocks formed by Air or Mud Volcanoes.*

In some countries, jets or great bubbles of water, highly impregnated with mineral matter, are thrown out of the earth by means of gas. The earthy matter is deposited in the state of mud, principally around the mouths of the cones from whence it is expelled; and as these cones somewhat resemble volcanoes in form, they have been named *air-volcanoes*. One of the most remarkable of these air-volcanoes hitherto described, is that of Macalouba in Sicily, of which an account has been published by Dolomieu. It consists of a hillock of hardened mud, about one hundred and fifty feet in height. Its superior part forms a plain more than half a mile in circumference, and rising from it are numerous small cones not more than three feet in height, each of which has a crater or hollow filled more or less deeply with a liquid mud, which is in a state of perpetual agitation, owing to the constant passage of great bubbles of air through it. Portions of the mud are constantly thrown out, and thus add to the bulk and height of the cones.

There are many small *mud-volcanoes* in the neighbourhood of Modena, whose height is not more than a few feet. They are named *Salses*, on account of the saltness of the water they throw out; and which, indeed, is also the case with the water of Macalauba, and of that of most other muddy eruptions observed in different countries. These volcanoes, during their paroxysms, which are attended with slight agitations of the earth, throw out much mud, which extends to the distance of three thousand feet. The gas which occasions the eruptions, is sulphuretted hydrogen mixed with petroleum, and a little carbonic acid. Similar air-volcanoes are described by Pallas as occurring in the Crimea, particularly in the island of Taman. In the year 1794, one of these burst with a noise like that of thunder, and flame and smoke rushed from it to the height of more than three hundred feet. Great masses of dried mud were projected from it to great distances, and it vomited forth currents of *a bituminous mud or slime*, to the amount of one hundred thousand cubic fathoms. Humboldt describes air-volcanoes which he saw in the middle of an elevated plain, in the province of Carthagena in South America. There were twenty small cones, having an eleva ion of from twenty-one to twenty-seven feet in height, and formed of bluish coloured clay. Their summits were hollow or crater-like, filled with water, from the surface of which air arose, and burst with an explosion, and often threw out mud. In the island of Trinidad, and also in Java, there are considerable air or mud volcanoes.

6. *Volcanic Rocks.*

These are the mineral substances formed or thrown out by true volcanoes when in a state of activity. The following are the most characteristic of these substances. 1. Lava; 2. Tuffa; 3. Volcanic ashes; 4. Volcanic glass.

1. *Lava.*—Many different kinds of lava are enumerated by geologists, and of which a particular account will be given in the *article* Volcano. For our present view it will be sufficient to arrange them under the following heads, viz. compact, vesicular, slaggy, and spumous.

a. Compact Lava.—Colour grey; massive, and sometimes in columnar distinct concretions. Lustre glimmering. Fracture uneven or splintery. Opaque. Semihard, approaching to hard. Brittle and easily frangible. Feels dry and rough. Sp. gr. = 2.80.

It always occurs in the form of streams, (coulè) and generally forms the middle part of the stream.

b. Vesicular Lava.—Colours grey, black, and brown. Structure vesicular. Generally occurs in the upper, and also on the under sides of streams of lava, when they have run over moist ground.

c. Slaggy Lava.—Colour black or brown, and has a completely slaggy aspect. It occupies the uppermost part of lava streams.

d. Spumaceous Lava.—Colour red or brown, and so very vesicular that it sometimes will float in water. Like slaggy lava, it always occurs on the surface of streams.

2. *Tuffa.*—Is a conglomerated volcanic rock, with an earthy basis, including masses of different kinds of lava, volcanic glass, &c.

3. *Volcanic Ashes.*—These are the loose powdery earthy matters thrown out when volcanoes are in a state of activity.

4. *Volcanic Glass.*—Certain varieties (if not all) of obsidian, described at page 476, are to be considered as volcanic glasses. These are lavas which have been in a state of perfect fusion.

*Veins.

Veins are tabular-shaped masses, that almost always traverse the direcion of the strata, and are composed of materials that either differ more or less from those of the rocks which they intersect, or are of the same nature.

1. External Relations of Veins.

Breadth and Extent of Veins.—Veins vary very much in their magnitude, yet the length and depth always bear a certain proportion to each other, and the breadth to the length and depth. The length and depth are frequently nearly alike, yet the length, on a general view, may be considered as generally somewhat more considerable than the depth.

1. *Breadth or width of Veins.*—In most metalliferous mountains, we find that metalliferous veins extend a few hundred fathoms, and then their width does not exceed two feet.

Veins whose width exceeds a few fathoms are to be considered as uncommon, and those whose width is still greater are to be viewed as exceptions to their general appearance. Humboldt and Friesleben observed veins of calc-spar 140 feet wide, traversing gneiss, in the valley of Lauterbrun, in the Alps of Switzerland. In the island of Arran we observed a vein of porphyry-slate nearly 160 feet broad, traversing sandstone. Born mentions that the Spitaler vein at Shemnitz, in Hungary, is from 14 to 15 fathoms wide. In that part of the Fichtelgebirge that belongs to Bavaria, there is a vein from 42 to 70 feet wide; and in the country of Holberg, near Rotleberode, there is a vein of fluor-spar 35 feet wide. In this country there are veins of pitchstone and greenstone from 10 to 100 feet wide.

The width of veins does not continue the same throughout, but changes considerably, and in some particular veins in a remarkable degree.

2. *Length of Veins.*—Veins differ very much in their length: when their length exceeds 6000 feet, it is to be considered as uncommon. The following may be mentioned as instances of metalliferous veins of uncommon length: The Halsbrückner-spath near Freyberg, which has been traced above four miles and a half; the Mordlauer-flach vein in the Fichtelgebirge, 9000 fathoms; and the Friedensgrubner-flach vein, in the same mountains, 5000 fathoms. Greenstone and pitchstone veins may be traced some miles in this country, as in the island of Arran.

3. *Depth of Veins.*—Few metalliferous veins reach above 200 fathoms below the surface of the mountains in which they are situated, and still fewer continue metalliferous to the depth of 300 fathoms. The following are instances of veins which are metalliferous at the depths mentioned:

	Fathoms.
The Küchschat vein near Freyberg, at .	207
The Junghohebirke vein near Freyberg, at .	158
The Thurmhofer vein, also near Freyberg, at	300
The Samson vein at Andreasberg, at .	250
The Thurmhofer-shaft at Clausthal, at .	312
The deepest shaft on a vein is that at Küttenberg in Bohemia, ...	500

4. That part of a vein which appears at the surface of a mountain is denominated its *outgoing* or *crop*; the directly opposite boundary, its *bottom*; and the lateral extremities, its *ends*. Those planes that bound the vein according to its greatest extent, are termed its *saalbande* or *sides*.

5. Veins continue in general in one direction. It must be understood that we here allude to the general direction. A vein of a mile in extent may stretch north and south in general, but there may be many deviations from that during so long a course.

6. Veins are usually much inclined, always more so than beds; the average inclination of beds is 45°, that of veins much higher. In inclined veins, the upper

side is denominated the *hanging side*, and the lower side the *lying side*.

2. Structure and Internal Relations of Veins.

1. The mass or body of a vein, as we have already observed, is almost always different from that of the rock which it traverses. In some cases, however, we discover resemblances between mountain-rocks and vein-stones. Instances of this kind are porphyry and granite.

2. A principal character of veins is their division into branches. The vein is sometimes divided into many branches by fragments of the *walls* (nebengestein;) or branches shoot out from the sides of the vein in different directions, and either terminate gradually in the rock at a greater or less distance from the vein, or, by winding, again join it.

It is observed that small veins usually terminate in the manner of these lateral branches; but large veins, on the contrary, divide into numerous branches at their ends and bottom, but less frequently at the bottom than at the ends.

3. The mass of the greater number of veins is separated from the rock through which it passes, by a very delicate seam; but in others this is not the case. Sometimes the sides of the vein are coated with a clayey substance, which is denominated *Besteg* by the German miners; but this does not always continue throughout the whole extent of the vein in which it occurs. In other cases the substance of the vein is intimately mixed with its walls.

4. Veins are composed either of earthy masses, as clay or loam, or rocks, as granite, clay-slate, alum-slate, porphyry, sandstone-conglomerate, sandstone, flœtz-limestone, coal, basalt, wacke, greenstone, pitchstone, porphyry-slate, or ores of different kinds. There is scarcely any species of ore that does not occur in veins.

5. Some veins are composed of but comparatively few minerals, and these are massive and intimately aggregated together; others are composed of a greater variety of minerals, but which show little regularity in their structure; and lastly, veins frequently occur, having a regular structure, where the different materials are arranged in layers parallel among themselves and to the walls of the vein; and these throw great light on the origin of veins, and on the formation of the minerals they contain.

When veins are composed of different layers, or are stratified, the same succession of layers is to be observed from both sides towards the middle. Each succeeding layer rests on the preceding, in such a manner that the crystals of the second layer are always impressed by those of the first. A beautiful example of the venigenous bedded structure occurs in the vein Hulfe-Gottes, at Gersdorf in Saxony. This vein is from six to nine feet wide, and is composed of parallel layers, which sometimes amount to forty in number. These layers are composed alternately of calc-spar, fluor-spar, lead-glance, grey copper-ore with fluor-spar, heavy-spar, and a very small portion of quartz. Similar appearances occur at Leadhills, and in many other mining districts.

In veins of this kind, in particular, we frequently meet with openings or unfilled spaces, which are generally situated towards the middle of the vein, and are by miners denominated *Druses*. They have usually a longish shape, and are always parallel with the vein. They have various contractions and widenings. They vary much in size, being from a few inches to several fathoms in magnitude. Their surface is covered with crystals, which are usually of the same minerals as those that form the massive part of the vein. Thus, the druses in veins composed of quartz, are lined with quartz-crystals; those in veins of brown-spar, with brown-spar crystals. When druses are lined with a variety of crystallizations of different minerals, we observe that the one series is laid on the other in a determinate order; the oldest part of the formation being that on which all the other crystals rest; the newest, that which covers all the others. Druses are sometimes filled with water; and when they are of great size, the quantity of water they contain is so considerable, as to endanger the lives of miners when they are cut into. It is also observed, that druses occur most abundantly, and of greatest size, in the upper part of veins, but become gradually smaller, and less numerous, in the deeper parts.

Veins composed of mountain-rocks sometimes present a stratified appearance. There are many interesting examples of this fact in the island of Arran. In that uncommonly interesting spot, wacke and greenstone occur in layers in the same vein. In other cases, veins are composed of layers of greenstone, porphyry-slate, and pitchstone. Other kinds of stratified veins occur in Arran and other parts of Scotland, which we shall take another opportunity of describing particularly.

6. Besides the drusy cavities, there sometimes occur very considerable open spaces in veins, that reach from the one side to the other, or from the hanging to the lying side.

7. When we attend to the masses of which veins are composed at different depths, we observe that they approach nearer and nearer to the centre, towards the lower part of the vein, but expand or recede from it in the upper part. Thus, those layers, which in the upper part of the vein are near to its sides, are at a considerable distance from them lower down, and, still deeper, approach nearer to the middle of the vein.

8. The appearances produced by the meeting, and intersecting of veins, are highly curious and important.

a. When a number of veins, that do not intersect one another, occur in the same district, it is observed that they have usually the same direction and constituent parts; thus intimating, that all of them are of the same general formation. When different venigenous depositions occur in the same district, then the direction of the veins of these different depositions is various, and they are arranged in such a manner, that each particular formation has a certain direction.

b. Veins running in different directions, either cross, or simply meet one another. When they cross, that which is crossed or intersected is said to be the *oldest*, and that which crosses or intersects, the *newest*, an opinion, the accuracy of which may be questioned.

c. Veins sometimes cross each other, without causing any change of direction; but more frequently we find the direction considerably changed.

d. When veins meet under an acute angle, the newer frequently traverses the older; runs parallel with it to a considerable extent, on its lower side, and then again diverges under the same angle it crossed it; sometimes the newer vein does not fully traverse the older, but changes its direction in the middle of the older vein; runs through the body of the vein; and after a longer or shorter course, again diverges at the same angle it entered. Sometimes the newer vein does not even traverse the older; only meets it; then runs parallel with it; again diverges; and this is sometimes frequently repeated in the course of the vein.

Sometimes newer veins do not ever run parallel with the older, but fairly terminate in them; and this takes place usually on the hanging or upper side.

9. In the same veins, we sometimes meet with two or three different formations. Thus, in some Saxon metalliferous veins, we find the lowest formation to be lead-glance; immediately above it, a formation of native silver; and the uppermost sparry-ironstone. In France, there are veins, whose lowest formation is copper-ores; immediately above it, a formation of silver-ore; and the uppermost is a formation of iron-ore. Many more examples of the same kind might be mentioned.

10. Great metalliferous veins usually run parallel with the general direction of great valleys.

11. Veins also occur more frequently in flat hilly country, than in steep mountainous country, and generally on the ridges of the hills. Beds, on the contrary, are equally, if not more abundant, in steep mountainous country.

12. Sometimes the strata or beds, traversed by veins, are merely separated; so that the strata or beds on opposite sides of the vein correspond. In other cases, there is a dislocation. or what miners call *a shift* of the strata, that is, the similar strata or beds on opposite sides of the vein do not correspond, but are depressed or sunk generally on the hanging or upper side of the vein. The degree of depression or dislocation usually corresponds to the magnitude of the vein.

13. The walls of veins are frequently more or less altered; and this alteration is caused either by an intermixture of the materials of the vein with that of the wall, or by a decomposition of the wall, owing to the agency of percolating water, or the substances of which the vein is composed.

Mode of formation.—Veins are either of simultaneous formation with the rock which they traverse, as in granite, metalliferous veins, &c. or are rents that have been filled up from above with the mineral matter they now contain, as in those veins that contain true fragments.

The various economical relations of veins will be discussed in the article Vein.

*** Age of Metals.

Age of Metals.—It appears from the details already given in our account of mountain-rocks,

1st, That metals differ very much as to the period of their formation

2d, That the variety and quantity of metalliferous substances decrease in general from the primitive to the alluvial period of the earth's formation.

3d, That molybdena, titanium, tin, scheele, cerium, tantalum, uran, chrome, and bismuth, are metals of the oldest primitive formation, and that only feeble traces of them are to be observed in newer periods.

4th, That although arsenic, cobalt, nickel, silver, and copper occur in old primitive mountains, they also extend to newer mountains.

5th, That gold, tellurium, antimony, and manganese, are metals of a middle age, occurring in the newer primitive, the transition, and the oldest secondary-rocks.

6th, That lead, zinc, and mercury, are of later date, when compared with those metals we have already mentioned, because they occur in greatest quantity in the newer or secondary formations.

7th, That iron is found in every rock, from the oldest granite to the newest alluvial deposit; hence is universally distributed, and is therefore a production of every period.

8th, That the more crystalline ores abound in the primitive mountains, but continue decreasing in quantity and variety from the primitive rocks to the newest alluvial deposits.

*** Theory of the Formation of the Earth.

This curious but very extensive subject cannot be discussed in the present article, but will be considered in all its bearings, and in connection with such new facts and views as may occur to travellers and geologists, or may result from our own investigations, under the article Theory of the Earth.

Part II. ORYCTOGNOSY.

This branch of mineralogy, as already explained, makes us acquainted with all the properties and relations of simple minerals. In treating this subject, we shall consider it in the following order:

1. Describe the character of simple minerals.
2. Explain the system of arrangement.
3. Describe the different species according to their external characters and chemical composition; and trace their geognostical and geographical distributions; and, lastly, explain their various uses.

1. *Characters of Simple Minerals.*

The characters of minerals are of different kinds, viz. *External*, *Chemical*, *Physical*, *Geognostical*, and *Geographical.*

1. *External Characters*,—are those which we discover by means of our senses, in the aggregation of minerals, and which have no reference to their relation to other bodies, or to chemical investigations.

2. *Chemical Characters*,—are those which are afforded by the complete analysis of the mineral, by trials with the various re-agents, the blowpipe, and the pyrometer.

3. *Physical Characters*,—are those physical phenomena which are exhibited by the mutual action of minerals and other bodies; such are the magnetic and electric properties exhibited by some minerals.

4. *Geognostical Characters*,—are those derived from various geognostic relations of minerals.

5. *Geographical Characters*,—are derived from the geographical distribution of minerals.

We shall first consider the external characters, and then the others, in the order already mentioned.

External Characters of Minerals.

The external characters of minerals are either *generic* or *specific*. The generic characters are certain properties of minerals used as characters, without any reference to their differences, as colour, lustre, or weight. The differences among these properties form the specific characters, as adamantine lustre, and glassy or vitreous lustre. The generic characters are divided into *general* and *particular*. Under the first, are comprehended those that occur in all minerals, whether solid, friable, or fluid: under the second, those which occur only in particular classes of minerals. In the following tabular view, the external characters are arranged nearly in a natural succession, and in the order in which they are employed in the descriptions of minerals.

A Tabular View of the Generic external characters of Minerals.

GENERAL GENERIC EXTERNAL CHARACTERS.

1. Colour.
2. The Cohesion of the Particles, according to which minerals are distinguished into

Solid, Friable, Fluid.

		Particular generic characters of Solid minerals.	Particular generic characters of Friable minerals.	Particular generic characters of Fluid minerals.
Characters for the sight.	External aspect.	External shape.	External shape.	
		External surface.		
		External lustre.		The lustre.
	Aspect of the fracture.	Lustre of the fracture.	The lustre.	
		The fracture.	Aspect of the particles.	
		Shape of the fragments.		
Characters for the sight.	Aspect of the distinct concretions.	Shape of the distinct concretions.		
		Surface of the distinct concretions.		
		Lustre of the distinct concretions.		Transparency.
	General aspect.	The transparency.		
		The streak.	The soiling.	Fluidity.
		The soiling.		
Characters for touch.		The hardness.		
		The tenacity.		
		The frangibility.	The friability.	
		The flexibility.		
		The adhesion to the tongue.		
For the hearing.		The sound.		

Remaining general generic external characters.

For the touch.
3. The Unctuosity.
4. The Coldness.
5. The Weight.

For the smell. 6. The Smell.

For the taste. 7. The Taste.

Colours of Minerals.

1. *Colours.*—We begin our description of the external characters of minerals with that of colour, as it is the character which first particularly strikes the eye. It exhibits very great variety, and hence its determination is often attended with considerable difficulty. Although it is an important and useful character, it was but ill understood before the time of Werner, and it is even at present, by some mineralogists, considered as of little or no value. The older mineralogists had no very accurate nomenclature of colours, and rarely gave any definition of them; hence it was, that this character, in their systems, did not afford satisfactory descriptions. Some modern mineralogists, particularly those of the French School, use, in their descriptions, only single, and often unconnected varieties of colour, which is an erroneous practice; because in describing species we ought to enumerate all the varieties they exhibit, and in a natural order, so that we may obtain a distinct conception of the arrangement of these varieties into groups or suites that characterise the species. Werner was early aware of the utility of this character, and, by a careful study of all its appearances and varieties, was enabled to form a system of colours for the discrimination of minerals, in which he established a certain number of fixed or standard colours, to which all the others could be referred, defined the varieties, and arranged them according to their resemblance to these standard colours, and placed them in such manner, that the whole colours in the system formed a connected series.

In establishing the fixed or standard colours, he thought he could not do better than adopt those as simple colours, which are considered as such in common life; of these he enumerates eight, which he denominates *chief* or *principal* colours; they are *white*, *grey*, *black*, *blue*, *green*, *yellow*, *red*, and *brown*. Although several of these colours are physically compound, yet, for the purposes of the oryctognost, it is convenient to consider them as simple.

Werner remarks, "I could not here enter into an adoption of the seven colours into which the solar ray is divided by the prism, as principal colours, nor into the distinction of the colours accordingly as they are either simple or compound; nor could I omit white and black, the former being considered as a combination of all colours, and the latter as the mere privation of light or colour; for these are distinctions that pertain to the theory of colours among natural philosophers, and cannot be well applied in common life, in which black is ranked among the colours as well as white and yellow; and green, which is mixed, considered as a principal colour, as well as red, which is simple.

"In the adoption of the principal colours enumerated above, I am countenanced by Dr. Schœffer, who has exhibited them, with the exception of the grey, in his sketch of a general association of colour, Regensburg, 1769. I am, however, justified in adding the grey colour, by observing, that it occurs very frequently in the mineral kingdom; that the attempt to bring it under any one of the other colours would be attended with many difficulties, and that, if we have respect to denominations, it is considered in common life as actually differing from the others." Werner's *External Characters*, p 38, 39.

Each of the principal colours contains one which is considered pure or unmixed with any other, and which is called the *characteristic colour*: thus, snow-white is the characteristic colour of white; ash-grey, of grey; velvet-black, of black; Berlin-blue, of blue; emerald-green, of green; lemon-yellow, of yellow; carmine-red, of red; and chesnut-brown, of brown.

Werner having thus established eight characteristic colours, he next defined and arranged the most striking subordinate varieties.

The definitions were obtained principally by occular examination, which enables us speedily to detect the different colours of which the varieties are composed. In detailing the results of this kind of *ocular analysis*, if we may use the expression, the predominant component parts are mentioned first, and the others in the order of their quantity. Thus apple-green is found to be a compound colour, and we discover, by comparing it with emerald-green, that it is principally composed of that colour and another, which is greyish-white: we therefore define apple-green to be a colour composed of emerald-green and a small portion of greyish-white. The method he followed in arranging the varieties is simple and elegant. He placed together all those varieties which contained the same principal colours in a preponderating quantity, and he arranged them in such a manner, that the transition of the one variety into the other, and of the principal colour into the neighbouring ones, was preserved. To illustrate this by an example: Suppose we have a variety of colour which we wish to refer to its characteristic colour, and also to the variety under which it should be arranged. We first compare it with the principal colours, to discover to which of them it belongs, which in this instance we find to be green. The next step is to discover to which of the varieties of green in the system it can be referred. If, on comparing it with emerald-green, it appears to the eye to be mixed with another colour, we must, by comparison, endeavour to discover what this colour is; if it prove to be *greyish-white*, we immediately refer the variety to *apple-green*; if, in place of *greyish-white*, it is intermixed with *lemon-yellow*, we must consider it *grass-green*; but if it contains neither greyish-white nor lemon-yellow, but a considerable portion of *black*, it forms *blackish-green*. Thus, by mere ocular inspection, any person accustomed to discriminate colours correctly, can ascertain and analyse the different varieties of colour that occur in the mineral kingdom.

The transition of the principal colours and their varieties into each other, he represents by placing the characteristic colours in the middle of a series of which all the members are connected together by transition, and whose extreme links connect them with the preceding and following principal colours. Thus, emerald green is placed in the middle of a series, the members of which pass, on the one hand, by increase of the proportion of blue into the next colour-suite, the blue; on the other hand, by the increase of yellow into yellow, siskin-green forming the connecting link with yellow, and verdigris green with blue.

Names of the Colours.

The names of the colours are derived, 1st, From certain bodies in which they most commonly occur, as milk-white, siskin-green, liver-brown; 2d, From metallic substances, as silver-white, iron-black, and gold-yellow; 3d, From names used by painters, as indigo-blue, verdigris green, and azure-blue; 4th From that colour in the composition which is next in quantity to the principal colour, as bluish-grey, yellowish-brown, &c.; and, 5th, From the names of persons, as Isabella-yellow, now called cream-yellow.

The principal colours are divided into two series, the one comprehending what Werner terms *bright colours*, the other *dead colours*; red, green, blue, and yellow, belong to the first; and white, grey, black, and brown, to the second. They may also be divided into *common colours*, as emerald-green, &c.; and into *metallic colours*, as gold-yellow, &c. The metallic colours are the most important as characters in describing minerals.

Arrangement of the colours.—The different characteristic colours and their varieties pass into each other, forming suites of greater or less extent, in which the colours either differ more and more from the first member of the series, as they approach the extremity, thus forming *straight series*, or, after reaching a certain point of greatest difference from the first colour, again gradually approach, and at length pass into it; thus forming *circular series*. In this way the eight principal colours pass into each other in the order in which we have already enumerated them, and thus form a straight series. The blue colour, however, after it has passed through green and yellow into red, passes from this latter colour by several intermediate varieties again into blue, thus forming a circular series or group.

In the system of colours, we do not introduce these various subordinate transitions and series, but simply arrange all the colours as they pass into each other, beginning with the white, and ending with the brown. The varieties of most of the different principal colours are so arranged, that their characteristic colour is placed in the middle of the series, and all those varieties that incline to the preceding principal colour are placed immediately after it; while those that incline to the next or following principal colour immediately precede it. This, however, is not the case with the white and grey colours; therefore the characteristic colours in those series do not stand in the middle; on the contrary, in the white it is placed at the beginning, and in the grey at the end.

I. *Definitions of the different Varieties of Colour.*

A. White.

This is the lightest of all the colours; hence the slightest intermixture of other colours becomes perceptible. The white colour occurs principally in earthy and saline minerals, seldom in metalliferous minerals, and very rarely amongst inflammable minerals. The following are the varieties of this colour:

a. *Snow-white* is the purest white colour, being free of all intermixture, and is the only colour of this suite which has no grey mixed with it. It resembles new-fallen snow. As examples of it, we may mention Carrara marble.

b. *Reddish-white* is composed of snow white, with a very minute portion of crimson-red and ash-grey. It passes into flesh-red. Examples, porcelain earth and rose quartz.

c. *Yellowish-white* is composed of snow-white, with very little lemon-yellow and ash-grey. It passes on the one side into yellowish-grey, on the other into straw-yellow. Examples, chalk, limestone, and semi-opal.

d. *Silver-white* is the colour of native silver, and is distinguished from the preceding by its metallic lustre. Examples, arsenical pyrites and native silver.

e. Greyish-white is snow-white mixed with a little ash-grey. Examples, quartz and limestone.

f. Greenish-white is snow-white mixed with a very little emerald-green and ash-grey. It passes into apple-green. Examples, amianthus, foliated limestone, and amethyst.

g. Milk-white is snow-white mixed with a little Berlin-blue and ash-grey. It passes into smalt-blue. The colour of skimmed milk. Examples, calcedony and common opal.

h. Tin-white differs from the preceding colour principally in containing a little more grey, and having the metallic lustre. It passes into pale lead-grey. Examples, native antimony and native mercury.

B. Grey.

This, which is one of the palest colours, is a compound of white and black, so that it forms the link by which these two colours are connected together, and is therefore placed between them. It occurs very frequently in the mineral kingdom. The following are its varieties.

a. Lead-grey is composed of light ash-grey with a small portion of blue, and possesses metallic lustre. It contains the following subordinate varieties.

α. *Whitish lead-grey.* It is a very light lead-grey colour, into the composition of which a considerable portion of white enters, and nearly approaches to tin-white. Examples, native arsenic on the fresh fracture.

β. *Common lead-grey.* It is the purest lead grey, with a slight intermixture of yellow. Examples, common grey antimony.

γ. *Fresh lead-grey.* It contains rather more blue than the preceding variety, with a slight tint of red, so that it has what is called a fresh or burning aspect. Examples, galena or lead-glance, and molybdena.

δ. *Blackish lead-grey.* Is common lead-grey mixed with a little black. Examples, silver-glance or sulphuretted silver, and copper-glance or vitreous copper.

b. Bluish-grey is ash-grey mixed with a little blue, or is lead-grey without metallic lustre. Examples, hornstone and limestone.

c. Pearl-grey is pale bluish-grey intermixed with a little red. It passes into lavender-blue. Examples, quartz, porcelain jasper, crystallized hornstone, and a very pale variety of pearl.

d. Smoke-grey or *brownish-grey*, is dark bluish-grey mixed with a little brown. Examples, flint, and some varieties of fluor-spar.

e. Greenish-grey is ash-grey mixed with a little emerald-green, and has sometimes a faint trace of yellow. It passes into mountain-green. Examples, clay-slate, whet-slate, potstone, sometimes mica, prehnite, and cat's-eye.

f. Yellowish-grey is ash-grey mixed with lemon-yellow and a minute trace of brown. It sometimes passes into cream-yellow and wood-brown. Examples, calcedony and mica.

g. Ash-grey is the characteristic colour. It is a compound of yellowish-white and brownish-black. It is the colour of wood-ashes. It passes on the one hand into greyish-black, on the other into greyish-white, as also into greenish, greyish, and smoke-grey. It seldom occurs pure in the mineral kingdom. Examples, quartz, flint, mica, and zoisite.

h. Steel-grey is dark ash-grey with metallic lustre. It is the colour of newly broken steel. Examples, grey copper and native platina.

C. Black.

It presents fewer varieties than any of the other colours, owing probably to the intermixture of lighter colours not being observable in it. The discrimination of its varieties is attended with considerable difficulty, and can only be satisfactorily accomplished after much practice. The following are its varieties:

a. Greyish-black is velvet-black mixed with ash-grey. It passes into ash-grey. Is very distinct in basalt.

b. Iron-black is principally distinguished from the preceding variety by its being rather darker, and possessing a metallic lustre. It passes into steel-grey. Examples, magnetic iron-ore and iron-mica.

c. Velvet-black is the characteristic colour of this series. It is the colour of black velvet. Example, obsidian.

d. Pitch-black, or *brownish-black*, is velvet-black mixed with a little yellowish-brown. It passes into blackish-brown. Example, earthy cobalt ochre and mica.

e. Greenish-black, or *raven-black*, is velvet-black mixed with a little greenish-grey. It passes into blackish-green. Example, hornblende.

f. Bluish-black is velvet-black mixed with a little blue. It passes into blackish-blue, and appears sometimes to contain a slight trace of red. Example, black earthy cobalt-ochre.

D. Blue.

The characteristic colour, which is Berlin-blue, is placed in the middle of the series, and all those varieties that contain red in their composition, on the one side, and those containing green, on the other. It is rarer among minerals than the preceding; blackish-blue connects it with black, sky-blue with green; and it is connected with red by violet-blue and azure-blue. The following are its varieties.

a. Blackish-blue is Berlin-blue mixed with much black and a trace of red. It passes, on the one side, into bluish-black, on the other, into azure-blue. Example, blue-copper, the dark varieties.

b. Azure-blue is Berlin-blue mixed with a little red. It is a burning colour. Examples, blue copper, and azure-stone.

c. Violet-blue is Berlin-blue mixed with much red and very little black. It borders on columbine-red. It is the tint of colour we observe in the violet when it is about to blow. It is the most frequent of the blue colours. Examples, Amethyst and fluor-spar.

d. Lavender-blue is violet-blue, intermixed with a small portion of grey. It is intermediate between pearl-grey and violet-blue. Examples, Lithomarge and porcelain-jasper.

e. Plum-blue is Berlin-blue, with more red than in violet-blue, and a small portion of brown and black. It passes into cherry-red and broccoli-brown. Example, Spinel.

f. Berlin-blue is the purest or characteristic colour of the series. Example, Sapphire, rock-salt and kyanite.

g. Smalt-blue is Berlin-blue with much white, and a trace of green. It passes into milk-white. It occurs in pale-coloured smalt, named eschel, also in earthy-blue iron, earthy blue copper, and in some varieties of gypsum.

h. Duck-blue is a dark blue colour, composed of blue, much green, and a little black. Frequently in ceylanite, and in a rare variety of indurated talc.

i. Indigo-blue, a deep blue colour, composed of blue, with a considerable portion of black and a little green. Example, earthy blue iron of Eckardsberg in Thuringia.

k. Sky-blue is a pale blue colour, composed of blue, green, and a little white. It forms the link which connects the blue series with the green. It is named mountain-blue by painters. It is the colour of a clear sky, and hence its name. It occurs but rarely in the mineral kingdom. Example, Lenticular copper.

E. Green.

The varieties of this colour naturally fall into two principal suites; in the one of which the blue colour prevails; in the other the yellow; and between the two is placed the pure or characteristic colour, the emerald-green. Although it is not a common colour in the mineral kingdom, yet it is met with more frequently than the blue. In earthy minerals, the green colours are generally owing to oxide of iron; in a few cases to the oxide of chrome; in others to oxide of copper; and in a very few to oxide of nickel.

The following are the varieties of this colour.

a. Verdigris-green is emerald green mixed with much Berlin-blue, and a little white. It is the link which connects the green and blue colours together. Examples, Copper-green and green Siberian felspar.

b. Celandine-green is verdigris-green mixed with ash-grey. Examples, Green earth, Siberian and Brazilian beryl.

c. Mountain-green is emerald-green, mixed with much blue, and a little yellowish-grey; or verdigris-green with yellowish-grey. It passes into greenish-grey. Examples, Beryl, aqua marine topaz, glassy actynolite, common garnet, and hornstone.

d. Leek-green is emerald green, with bluish-grey and a little brown. It is the sap-green of painters. In this colour the blue and yellow colours are in equal proportions. Examples, Nephrite, common actynolite, and prase.

e. Emerald-green. The characteristic or pure unmixed green. All the preceding green colours are more or less mixed with blue, and at length pass into it; but the following part of the green series, by the increasing proportion of yellow, at length passes into yellow. Examples, Emerald, fibrous malachite, copper-mica, and sometimes also fluor-spar.

f. Apple-green is emerald-green mixed with a little greyish-white. It passes into greenish white. Examples, Nickel ochre and chrysoprase.

g. Grass-green is emerald green mixed with a little lemon-yellow. The colour of fresh newly sprung grass. Example, Uranite.

h. Blackish-green is pistachio-green mixed with a considerable portion of black. It passes into greenish-black. Examples, Precious serpentine and augite.

i. Pistachio-green is emerald-green mixed with more yellow than in grass-green, and a small portion of brown. Examples, Chrysolite, and epidote or pistacite.

k. Asparagus-green is pistachio-green mixed with a little greyish white; or emerald-green mixed with yellow and a little brown. It passes into liver-brown. Examples, Garnet, olivenite and beryl.

l. Olive-green is grass-green mixed with much brown and a little grey. It passes into liver brown. Examples, Common garnet, olivenite, pitchstone, and epidote or pistacite.

m. Oil-green is emerald-green mixed with yellow, brown, and grey; or pistachio-green, with much yellow and light ash-grey. It is the colour of fresh vegetable oil. Examples, Fuller's-earth, beryl and pitchstone.

n. Siskin-green is emerald-green mixed with much lemon-yellow and a little white. It makes the transition to the yellow colour. Examples, Uran-mica, green lead-spar and steatite.

F. Yellow.

Among the varieties of this species of colour, there are three possessing metallic lustre, viz. brass-yellow, gold-yellow, and bronze-yellow. The characteristic colour, which is lemon-yellow, is placed in the middle of the series; the colours which precede it are greenish-yellow, and those which follow it are reddish-yellow. The one side of the series, by the increase of the green, passes by sulphur yellow into green; the other, by the increase of red, passes, by means of orange-yellow, into red. It is a frequent colour in the mineral kingdom. The following are its varieties.

a. Sulphur-yellow is lemon-yellow mixed with much emerald green and white. It is the colour of native sulphur. Example, Native sulphur.

b. Brass-yellow differs from the preceding colour principally in having a metallic lustre; it contains a small portion of grey. Example, Copper-pyrites.

c. Straw-yellow is sulphur-yellow mixed with much greyish white. It passes into a yellowish-white and yellowish-grey. Example, Calamine, serpentine and yellow cobalt-ochre.

d. Bronze yellow is brass-yellow mixed with a little steel-grey, and a minute portion of reddish brown. The colour of bell-metal. Example, Iron-pyrites.

e. Wax yellow is lemon-yellow mixed with reddish-brown, and a little ash-grey; or it may be considered as honey-yellow with greyish white. It is the colour of pure unbleached wax. Examples, Opal and yellow lead-spar.

f. Honey-yellow is sulphur-yellow mixed with chestnut brown. It passes into yellowish brown. Examples, Fluor-spar and beryl.

g. Lemon-yellow is the pure unmixed colour. It is the colour of ripe lemons. Examples, Yellow orpiment.

h. Gold-yellow is the preceding colour with metallic lustre. Example, Native gold.

i. Ochre-yellow is lemon-yellow mixed with a considerable quantity of light chestnut brown. It passes into yellowish brown. It is a very common colour among minerals. Examples, Yellow earth and jasper.

k. Wine-yellow is lemon-yellow mixed with a small portion of red and greyish-white. The colour of Saxon home-made wine. Examples, Saxon and Brazilian topaz.

l. Cream-yellow or *Isabella-yellow.* It contains more red and grey than the wine-yellow, and also a little brown. It passes into flesh-red. Examples, Bole from Strigau, and compact limestone.

m. Orange-yellow is lemon-yellow with carmine red. It is the colour of the ripe orange. Examples, Streak of red-orpiment, and uran-ochre.

G. Red.

It exhibits more varieties than the other colours, and is very common in the mineral kingdom. The characteristic colour is carmine-red; all the others incline either to yellow or blue: hence there are two principal suites; the first of which contains yellowish-red colours; the second bluish-red colours. The red colours are principally owing to oxides of iron, manganese and cobalt, and combinations of metals with sulphur and arsenic. The following are the varieties.

a. Aurora or *morning red* is carmine-red mixed with much lemon yellow. It passes into orange-yellow. Example, Red orpiment.

b. Hyacinth-red is carmine-red mixed with lemon-yellow and a minute portion of brown; or aurora-red mixed with a minute portion of brown. It passes into brown. Examples, Hyacinth and tile-ore.

c. Tile red is hyacinth-red, mixed with greyish-white. It is the colour of tiles or bricks. Examples, Porcelain-jasper and zeolite.

d. Scarlet red is carmine-red mixed with a very little lemon-yellow. It is a well-known colour of much intensity. Example, Light-red cinnabar from Wolfstein.

e. Blood-red is scarlet-red mixed with a small portion of black. Examples, Pyrope and jasper.

f. Flesh-red is blood-red mixed with greyish-white. Examples, Felspar, calcareous spar, and straight lamellar heavy spar.

g. Copper-red. It scarcely differs from the preceding variety, but in possessing a metallic lustre. Examples, Native copper and copper-nickel.

h. Carmine-red is the characteristic colour. Example, Spinel particularly in thin splinters.

i. Cochineal-red is carmine-red mixed with bluish-grey. Examples, Dark-red cinnabar and red copper-ore.

k. Crimson-red is carmine-red mixed with a considerable portion of blue. Example, Oriental ruby.

l. Columbine-red is carmine-red, with more blue than the preceding variety, and, what is characteristic for this colour, a little black. Example, Precious garnet.

m. Rose-red is cochineal red mixed with white. It passes into reddish-white. Examples, Red manganese and quartz.

n. Peach blossom-red is crimson-red mixed with white. Example, Red cobalt-ochre.

o. Cherry-red is crimson red mixed with a considerable portion of brownish-black. Examples, Spinel, red antimony, add precious garnet.

p. Brownish red is blood-red mixed with brown. It passes into brown. Example, Clay ironstone.

H. Brown.

This, after black, is the darkest colour in the system. The whole species or suite can be distinguished into those which have red, and those which have yellow mixed; between these is placed the fundamental colour, the pure unmixed chestnut-brown, and the last variety, from the quantity of black it contains, connects the brown series with the black. Varieties of this colour occur frequently in the mineral kingdom, particularly among the ores of iron, and the inflammable minerals.

a Reddish-brown is chestnut-brown mixed with a little red and yellow; or chestnut-brown with a small portion of aurora-red. It passes into brownish-red. Example, brown blende from the Hartz, and zircon.

b. Clove-brown is chestnut-brown, mixed with cochineal-red, and a little black. It is the colour of the clove. It passes into plum-blue and cherry-red. Examples, rock-crystal, brown hematite, and axinite.

c. Hair-brown is clove-brown mixed with ash-grey. Examples, Cornish tin-ore, wood opal, and brown iron-ore.

d. Broccoli-brown is chestnut-brown mixed with much blue, and a small portion of green and red. It passes into cherry-red and plum-blue. It is a rare colour. Example, zircon.

e. Chestnut-brown. Pure brown colour. It is a rare colour. Example, jasper.

f. Yellowish-brown is chestnut-brown mixed with a considerable portion of lemon-yellow. It passes into ochre-yellow. It is one of the most common colours in the mineral kingdom. Examples, iron-flint and jasper.

g. Pinchbeck-brown is yellowish brown with metallic lustre. Rather the colour of tarnished pinchbeck. Example, mica.

h. Wood-brown is yellowish-brown mixed with much pale ash-grey. It passes into yellowish-grey. Mountain wood, and bituminous wood.

i. Liver-brown is chestnut-brown mixed with olive-green and ash-grey. It is the colour of boiled, not fresh liver. It passes into olive green. Example, common jasper.

k. Blackish-brown is chestnut-brown mixed with black. It passes into brownish-black. Examples, mineral pitch from Neufchatel, moor-coal, and bituminous wood.*

The immense variety of colours that occur in the mineral kingdom, constitute an almost infinite series, to characterise every individual of which is next to impossible. The colours we have already defined, are a few only of the most prominent features of that great and beautiful series, and serve as points of comparison, and as the boundaries between which every occurring colour lies.

From the small number of colours we have defined, and the great variety that occur in minerals, it is evident that the greater number of occurring colours will not correspond exactly with those defined, but will lie between them. It is this circumstance, in particular, that renders it so difficult to get an acquaintance with colours. To obviate this, in some degree, Werner uses terms which express correctly certain prominent differences which are to be observed between every two colours. Thus, when one colour approaches slightly to another, it is said to *incline* towards it, (es näert sich;) when it stands in the middle between two colours, it is said to be *intermediate*, (es steht in der mitte,) when,

* The most accurate delineations of colours are given in Syme's Wernerian Nomenclature of Colours, published in Edinburgh a few years ago.

on the contrary, it evidently approaches very near to one of the colours, it is said to *fall* or *pass* into it, (es geht über.)

II. *The Delineations or Patterns formed by the Colours.*

The distinctions included under this head depend on the shape which the colour assumes. It is only to be observed in simple minerals. The following are the different kinds enumerated and described by WERNER.

A. *Dotted.* In this variety, dots or small spots are irregularly dispersed over a surface which has a different colour from the spots. It occurs frequently in serpentine, but seldom in other minerals.

B. *Spotted.* If the spots are from a quarter of an inch to an inch in diameter, and the basis or ground still visible, it is said to be spotted. It is either *round* and *regularly spotted*, or *irregularly spotted.* The first occurs in clay-slate; the second in marble.

C. *Clouded.* Here no basis is to be observed; the boundaries of the colours are not sharply marked, and the spots run into each other. It occurs in marble and jasper.

D. *Flamed.* When the spots are long and acuminated, and arranged according to their length, the flamed delineation is formed. It has still a basis. It occurs in striped jasper, marble, &c.

E. *Striped.* Consists of long and generally parallel stripes, that touch each other and fill up the whole mass of the stone, so that it has no ground. It presents two varieties.

a. *Straight striped*, as in striped jasper and variegated clay.

b. *Ring-shaped*, occurs in Egyptian jasper.

F. *Veined.* Consists of a number of more or less delicate veins crossing each other in different directions, so that it is sometimes net-like. We can always distinguish a base or ground. Examples, black marble veined with calcareous spar or quartz, jasper and serpentine.

G. *Dendritic.* Represents a stem with branches, on a ground. Examples, steatite and dendritic calcedony.

H. *Ruiniform.* Resembles ruins of buildings. It occurs in Florentine marble, which is from this circumstance called *landscape marble.*

III. *The Play of the Colours.*

If we look on a mineral which possesses this property, we observe, on turning it slowly, besides its common colours, many others, which are bright, change very rapidly, and are distributed in small spots or patches. A strong light is required, in order to see this appearance distinctly, and it never occurs in opaque or feebly translucent minerals. We observe it in the diamond when cut, and in precious opal.

IV. *The Changeability of the Colours.*

When the surface of a mineral, which we turn in different directions, exhibits, besides its common colours, different bright colours, that do not change so rapidly, are fewer in number, and occur in larger patches than in the play of the colour, it is said to exhibit what is called the changeability of the colours. The changeability of colour is seen only in particular directions, the play of colour in all directions.

We distinguish two kinds of this phenomenon.

A. That which is observed by looking in different positions *on* the mineral, as in Labrador felspar.

B. That observed by looking *through* it, as in the common opal, which shows a milk-white colour when we look on its surface, but when held between the eye and the light is wine-yellow.

V. *The Iridescence.*

When a mineral exhibits the colours of the prism or the rainbow, arranged in parallel, and sometimes variously curved layers, it is said to be iridescent. It is to be observed by

A. Looking *on* the mineral only, as in precious opal, adularia, &c.

B. Both by looking on the mineral and through it, as in calcareous spar, crossed by thin veins, some arragonites, rainbow calcedony, and some amethysts.

VI. *Tarnished Colours.*

A mineral is said to be tarnished, when it shows on its external surface, or on that of the distinct concretions, fixed colours different from those in its interior or fresh fracture.

There are *simple* or *variegated* tarnished colours.

a. *Simple.*

α. *Grey*,—white cobalt.

β. *Black*,—native arsenic.

γ. *Brown*,—magnetic pyrites.

δ. *Reddish*,—native bismuth.

b. *Variegated.*

The variegated or party-coloured, are distinguished according to the intensity of their basis. Of these the following are enumerated in the tabular view.

α. *Pavonine*, or *Peacock-tail tarnish.* This is an assemblage of yellow, green, blue, red, and brown colours, on a yellow ground. The colours are nearly equal in proportion, and are never precisely distinct, but always pass more or less into one another. Example, copper-pyrites.

β. *Iridescent*, or *Rainbow.* In this variety the colours are red, blue, green, and yellow, on a grey ground. It is more beautiful and brighter than the preceding. The radiated grey antimony of Felsobanya in Hungary, and the specular iron-ore, or iron-glance of Elba, are often beautifully iridescent.

γ. *Columbine*, or *pigeon-neck tarnish.* The colours are the same as in the preceding, with this difference, that the tints of colour are paler, and the red predominates. Examples, native bismuth of Schneeberg.

δ. *Tempered-steel tarnish.* It consists of very pale blue, red, green, and very little yellow, on a grey ground. Example, grey cobalt.

VII. *The Permanent Alterations.*

These must not be confounded with the tarnished colours. The tarnish occurs only on the surface; the permanent alteration, on the contrary, proceeds by degrees through the whole mass of the mineral. This change takes place more or less rapidly in different minerals. The colours either become paler, when they are said to *fade*, or they become darker, and pass into other varieties. Thus chrysoprase, rose quartz, and red cobalt-ochre become paler; whereas sky-blue fluor-spar becomes green, pearl-grey corneous silver sometimes changes to brown, and lastly into black, and earthy blue iron changes from white, through different varieties of blue, to indigo-blue.

PARTICULAR GENERIC EXTERNAL CHARACTERS.

I.—PARTICULAR GENERIC EXTERNAL CHARACTERS OF SOLID MINERALS.

Characters for the Sight.

1. The External Aspect.

The External Aspect of a mineral is that outline or contour which it has received from nature. Thus, if we have a piece of lead-glance, as it has been found loose, or imbedded in another mineral, we name the surface which it has received from nature, its Aspect. All those characters which we can discover by the eye, on this outline, are denominated the External Aspect of the mineral. They are of three kinds: 1. The External Shape: 2. The External Surface; and, 3. The External Lustre.

1. *The External Shape,*

Is divided into four classes,

1. Common
2. Particular
3. Regular
4. Extraneous

} External Shape.

All of these classes have their subordinate differences, which we shall now describe; and,

I. *Common External Shape.*

Common External Shapes are those in which there are neither a determinate number of planes meeting under determinate angles, nor any resemblance to known natural or artificial bodies. As they occur more frequently than the other shapes, they are named Common External Shapes.

Six different kinds are enumerated by Werner, which are distinguished according to their relative length, breadth, and thickness, their relative magnitude, and their connections with other minerals. The kinds are *massive*, *disseminated*, *in angular pieces*, *in grains*, *in plates*, and *in membranes*.

A. *Massive*, is that common external shape which is from the size of a hazel-nut to the greatest magnitude, and whose dimensions in length, breadth, and thickness, are nearly alike. It occurs imbedded in other minerals, and it is intermixed with them at their line of junction. Examples, Galena or lead-glance, and copper pyrites.

Many of the varieties of this form are crystallized, although they do not appear so to the eye. This curious fact has been lately well elucidated by Mr. Daniell. He remarks, that if a lump or massive piece of alum, or borax, or of nitre, be immersed in a vessel of water, and left at rest for three or four weeks, the solution will be found to have gone unequally on; the uppermost portion will be found most wasted, and the undermost least; so that the undissolved part of these salts will have assumed a conical form. The lower part of these bodies, after this treatment, will be found embossed over with numerous crystalline forms. These in alum are octahedrons, or figures formed by different sections of the aluminous octahedron. In borax they are fragments of eight-sided prisms, and so on. Mr. Daniell has shewn, in a satisfactory way, that these embossments are not formed by the crystallization of that portion of the salt which has been dissolved; but that they are brought into view by the unequal solution of the lump of salt subjected to the action of the water. Hence it follows, that all these apparently amorphous masses are in reality composed of crystals, though such a structure cannot be distinguished by the eye previous to this natural dissection of it. The same crystalline structure was developed when calcareous-spar, strontian, and witherite, were acted on by vinegar. Bismuth, antimony, and nickel, treated with very dilute nitric acid, likewise exhibited a crystallized structure. From these experiments we may infer, with considerable probability, that the structure of most minerals is in reality crystallized, even when they appear massive; an inference which leads to the highly important conclusion, that, on a general view, a great portion of the crust of the earth is more or less of a crystalline nature.

B. *Disseminated*, is from the size of a hazel-nut until it is scarcely visible, and its dimensions in length, breadth, and thickness are nearly alike. It is imbedded, and is intermixed with the inclosing mineral at the line of junction. It is divided into

a. Coarsely disseminated, which is from the size of a hazel-nut to that of a pea. Examples, Copper-pyrites and brown-spar.

b. Minutely disseminated, from the size of a pea to that of a millet-seed. Example, Tinstone in granular quartz.

c. Finely disseminated, from the size of a millet-seed until it is scarcely visible. Example, Brittle silver glance in brown spar.

C. *In angular pieces.* Minerals having an angular shape, in which the length, breadth, and thickness are nearly alike, which are found loose, or slightly imbedded, and without any intermixture with the inclosing mineral at the line of junction, and from the size of a hazel-nut and upwards, are said to occur in angular pieces. It is distinguished from the massive by its occurring either loose, or not intermixed with the basis at the line of junction. Of this external shape there are two kinds.

a. Sharp cornered, as in quartz and calcedony.

b. Blunt cornered, as in common opal.

D. *In grains.* Minerals having a roundish form, and imbedded or loose, and not much larger than a hazel-nut, are said to occur in grains. This shape is distinguished,

a. With regard to size, into

α. Large, that is, when they are from the size of a hazel-nut to that of a pea. Examples, meadow ore and precious garnet.

β. Coarse, from the size of a pea to that of a hemp-seed. Example, Pyrope.

γ. *Small*, from the size of a hemp-seed to that of a millet-seed. Examples, Precious garnet, Pyrope and iron-sand.

δ. *Fine*, from the size of a millet seed until it becomes nearly undistinguishable. Example, Platina.

The grains are further distinguishable,

b. With regard to the exacter determination of the shape, into

α *Angular grains*, as in iron-sand.

β. *Flattish grains*, as in platina and gold.

γ. *Roundish grains*, as in pyrope and precious garnet.

c. With regard to connection with other minerals.

α In loose grains.

β In imbedded grains.

γ. In superimposed grains.

E. *In plates*. Minerals which occur in external shapes, whose length and breadth are great in comparison of their thickness, in which the thickness is not equal throughout, and is so considerable, as to allow the fracture to be distinguished, are said to occur in plates. The maximum thickness of plates is half an inch. Example, red silver.

F. *In membranes* or *flakes*. This shape is distinguished from the former by its thinness, as it never greatly exceeds the thickness of common paper, and the fracture cannot be seen. Example, iron-pyrites.

II. *Particular External Shape.*

Particular external shapes differ from the common external shapes, in bearing a resemblance to natural or artificial bodies, and in being far more characteristic and varied in their aspect. They are called *particular*, because they are not so common among minerals as the common external shapes. There are four different sets, entitled *longish*, *roundish*, *flat*, and *cavernous*. Each of these sets have their subordinate kinds, which we shall now describe.

A. *Longish Particular External Shapes.*

a. *Dentiform*, adheres by its thick extremity, and becomes gradually thinner, incurvated, and at length terminates in a free point, so that it resembles a canine tooth, whence its name. Its length is from a quarter of an inch to a foot. It is one of the rarer kinds of external shapes, and is peculiar to certain metals. Example, Native silver.

b. *Filiform*, adheres by its thicker extremity, and terminates by an almost imperceptible diminution of thickness, and is usually curved in different directions It is thinner and longer than the dentiform. Example, Native silver.

c. *Capillary*. When the filiform becomes longer and thinner, it forms the capillary. It is generally much entangled, and sometimes the threads are so near each other that it passes into the compact. Example, Native silver.

d. *Reticulated*, is composed of many straight threads, which are sometimes parallel, and sometimes meet each other at right angles, and form a net like shape. The whole is a series of minute crystals, and is distinguished from the capillary by its threads being always straight. Example, Native silver.

e. *Dendritic*. In this external shape we can observe a trunk, branches, and twigs, which are distinguished from each other by their thickness, the trunk being the thickest. Examples, Native copper and brown hematite.

f. *Coralloidal* or *coralliform*. When two or three branches, having rounded or pointed extremities, proceed from one stem, the coralloidal external shape is formed. There are usually many stems together. From its resemblance to coral, it is denominated Coralloidal. The variety of arragonite, called *flos ferri*, is an excellent example of this kind of particular external shape.

g. *Stalactitic*. A mineral is said to possess a stalactitic external shape, when it consists of different straight more or less lengthened rods, which are thickest at their attachment, and become narrower at their free extremity, which is rounded or pointed. Example, calc-sinter.

h. *Cylindrical* consists of long, rounded, straight, imperforated, usually parallel rods, which are attached at both extremities, and are generally thicker at the extremities than the middle. The interstices are either empty, or filled up with another mineral. Examples, galena or lead-glance and brown iron-ore.

i. *Tubiform* consists of long, usually single, perforated tubes, which are somewhat longitudinally knotty. Example. calc-sinter.

k. *Claviform* is the reverse of stalactitic; it is composed of club-shaped parallel rods, which adhere by their thin extremities. Example, compact black hematite.

l. *Fructicose*. This external shape is formed when many branches issue from a common stem and meet together partywise, so that the whole when viewed from above has a fructicose aspect, not unlike the appearance of cauliflower. Examples, calc-sinter and black hematite.

B. *Roundish Particular External Shapes.*

a. *Globular*. Under this are comprehended.

α. *Perfect globular* or *spherical*, as in alum-slate and pisiform iron.

β. *Imperfect globular*, as in calcedony.

γ. *Ovoidal* or *elliptical*. Example, rounded masses of quartz in puddingstone.

δ. *Spheroidal*. When the spherical is compressed the spheroidal is formed. Example, Egyptian jasper.

ε. *Amygdaloidal*. When the ovoidal is compressed in the direction of its length, the amygdaloidal is formed. Examples, zeolite, calcareous-spar and green earth.

b. *Botryoidal* consists of large segments of small balls, which are regularly heaped together, and have many interstices. It resembles grapes, whence its name. Examples, hematite, and calcedony.

c. *Reniform* consists of small segments of large balls, which are so closely set together, that no interstices are formed. Example, calcedony.

d. *Tuberose*. This shape consists of irregular roundish or longish elevations and depressions. Example, flint.

e. *Fused-like* or *liquiform*. It consists of numerous very flat rounded elevations, which are generally depressed in the middle. The whole has a rough and glimmering surface, and resembles the surface of slowly cooled metal. Example, lead-glance.

C. *Flat Particular External Shapes.*

a. *Specular* has on one side, seldom on two opposite sides, a straight smooth shining surface. It occurs in veins. Example, galena or lead-glance.

b. *In leaves.* In this external shape there are thin leaves, which are either irregularly curved, or are straight, and have throughout the same thickness. It is distinguished from the external shape in membranes by the uniformity of its thickness, by its irregular curvatures, its continuity, (the membranous external shape being often interrupted,) and its usual adherence by one extremity, showing that it is a kind of crystalline shoot. It occurs frequently in native gold.

D. *Cavernous Particular External Shapes.*

a. *Cellular.* A mineral is said to be cellular, when it is composed of straight or bent tables, which cross together in such a manner as to form empty spaces or cells. Example, quartz.

b. *Impressed.* That is, when one mineral shows the impression of any particular or regular external shape of another mineral. It borders on the cellular shape, and is formed when a newer mineral is deposited over an older, the form of which it assumes, and retains even after the impressing mineral has been destroyed or removed.

a a. *With impressions of crystals.*

α. *Cubical*, as in quartz or iron-pyrites, from fluor-spar.

β. *Pyramidal*, as in hornstone, originating from calcareous-spar.

γ. *Tabular*, as in quartz, originating from heavy spar.

b b. *With impressions of particular external shapes.*

α. *Conical*, in native arsenic.

β. *Globular*, in silver-glance or sulphuretted silver, from red-silver ore.

γ. *Reniform*, in silver-glance or sulphuretted silver, from red silver-ore.

c. *Perforated*, consists of long vermicular cavities, which occupy but an inconsiderable portion of the mass, and terminate on the surface in small holes. When the holes become very numerous, it passes into spongiform. Example, bog iron-ore.

d. *Corroded.* A fossil is said to be corroded, when it is traversed with numerous hardly perceptible roundish holes. The volume occupied by the holes is nearly equal to that of the basis. It has the appearance of wood which has been gnawed by insects. Examples, quartz, galena or lead-glance, and silver-glance or sulphuretted silver.

e. *Amorphous* is composed of numerous roundish and angular parts that form inequalities, between which there are equally irregular hollows. The whole has the appearance as if a number of small balls and angular pieces were heaped on one another. Examples, silver-glance or sulphuretted silver, and meadow-ore.

f. *Vesicular* When a mineral has distributed through its interior many single, usually round, elliptical, and spheroidal, also amygdaloidal, or irregular-shaped cavities, it is said to be vesicular. The cavities are usually less in volume than the solid part of the mineral, and they are larger than the holes or cavities in the corroded external shape. Examples, wacke and lava.

E. *Entangled Particular External shape.*

a. *Ramose.* It is composed of longish, angular, more or less thick branches, that are bent in different directions, but in which no trunk or common stem is to be observed. It probably originates from the greater magnitude of the vesicles in the vesicular, the vesicles breaking into each other. Examples, meteoric-iron, silver-glance or sulphuretted silver, and native copper.

III. *Regular External Shape or Crystallization.*

Every external shape, whose natural contour or outline is composed of a determinate number of planes, which meet together in a determinate manner, is denominated a crystal.

In describing crystals, we have to consider, *A. Their Genuineness; B. Their Shape; C. Their Magnitude; D. Their Attachment.*

A. The Genuineness of Crystals.

This refers to the division of crystals into *True* and *Supposititious*. The *true* are the forms which the same substance always assumes, and which are peculiar to it; the *supposititious* are those regular figures whose shape does not depend on the substance of which they are composed, but is owing to pre-existing crystals, or crystal-moulds.

Supposititious crystals are formed in two ways:

1. When an imbedded crystal falls out and leaves an empty mould, which is afterwards filled up with fossil matter, a figure or crystal corresponding in shape to the mould is formed. The supposititious crystals formed in this manner are smoother, and have sharper edges and angles than the succeeding kind, and their interior is often hollow and drusy.

2. When a mineral is deposited over a pre-existing crystal, and assumes its figure, the second kind of supposititious crystal is formed. The pre-existing crystal either remains, forming the nucleus, or it disappears when the supposititious crystal is hollow. It differs from the first kind in having generally a rough and drusy surface, blunter edges and angles, and the inner surfaces smooth.

The first kind of supposititious crystal is a cast or filling of the space formerly occupied by true crystals; the second is merely an incrustation of true crystals*.

True and supposititious crystals are distinguished from each other by the following characters:

a. *True crystals,*

α. Are transparent and semitransparent.

β. Their planes are smooth and shining or splendent, or they are regularly streaked.

γ. Their angles and edges are sharp.

δ. Are seldom drusy upon the surface; but when this is the case, it is remarked that all the axes of the small crystals forming the drusy surface are in the same position.

ε. They form particular characteristic suites.

b. *Supposititious crystals.*

α. The planes are never smooth and shining, or

* A third kind of crystal has been particularly pointed out by Breithaupt. He names it the *metamorphosed or changed crystal;* the form is not altered, but the substance is changed by certain processes hitherto but imperfectly known. Thus, cubes of iron pyrites are changed into cubes of brown iron-stone, and crystals of augite, without any change of form, are converted into chlorite, or green earth.—Vide *Ueber die Aechtheit der Krystalle,* von A. Breithaupt, Freiberg, 1815.

regularly streaked; on the contrary, are generally rough and dull.

β. The angles and edges are not so sharp as in true crystals, but are generally somewhat rounded.

γ. They are usually hollow, and their internal surface is drusy.

δ. They are almost always drusy, internally, in those formed by moulding; externally, in those formed by incrustation; and it is remarked, that the small crystals forming the drusy surfaces are disposed irregularly.

ε. They are not, like true crystals, connected by transitions with other crystals of the same species: Thus the octahedral supposititious crystals of quartz, which originate from fluor-spar, do not belong to the suite of quartz.

ζ. Even in their internal structure they are different from true crystals; for they seldom present a fracture inclining to foliated.

η. Single crystals are never all around crystallized.

The following are well known instances of supposititious crystals.

1. Octahedral crystals of quartz, originating from fluor-spar.
2. Cubic crystals of quartz, from fluor-spar.
3. Flint in double three-sided pyramids, from calcareous-spar.
4. Quartz in oblique four-sided tables, from heavy-spar.

B. The Shape of Crystals.

The shape of crystals is determined by the number and form of the planes or faces, and the edges and angles which form the contour or outline*. Amidst the great variety of crystals that occur in the mineral kingdom, there are some simple ones, which are composed of but few planes, that do not vary much in shape; and of others, in which the planes are not only numerous, but present great differences in form. These simple forms are nearly allied to the more complex ones, and gradually pass into them by a change in the shape of their planes. On this circumstance Werner has founded a crystallographic system, remarkable for its simplicity, and the ease with which it enables us to acquire distinct conceptions of the most complicated crystallizations. He considers these simple forms as the basis of the others, and names them *Fundamental figures.* We can distinguish in them one, or at the utmost, two sets of planes, which run in two directions, and enclose the crystal on all sides. The cube is an example of a fundamental figure with one set of planes; the prism, pyramid and table, are examples of fundamental figures with two sets of planes, which are named *lateral* and *terminal planes.* All those crystals in which we observe many different sorts of planes, he considers as changed or altered fundamental figures; and names the other planes, which are generally smaller, and differ from the planes of the fundamental figure in direction, and in being further removed from the centre of the crystal, *Alterating planes.* We have thus, according to this method, to consider, first, *The Fundamental Figures,* and then their *Alterations* or *Modifications.*

I. The Fundamental Figures.

The fundamental figures, as already mentioned, are composed of one or two sorts of planes. In order to discover these planes in the altered fundamental figures, we have only to conceive the planes that lie nearest the centre of the crystal, and which are generally the largest, extended on all sides until they join.

In the fundamental figure are observed and attended to, I. *Its Parts.* II. *Its Varieties or Kinds.* III. *The Differences of each Fundamental Figure in Particular.*

I. *Parts of the Fundamental Figures.*

The fundamental figure is composed of *lateral* and *terminal planes*; of *lateral* and *terminal edges*; and of *solid angles*.

1. *Lateral planes* are the greatest planes that bound the smallest extent. *Terminal planes* are the smallest planes that bound the greatest extent. In the prism they form the *bases*, but in the table they are the smaller planes that surround the two largest planes.
2. *Lateral edges* are formed by the junction of two lateral planes, as in the prism and pyramid; but in the table, where the lateral planes do not meet, the lateral edges are those formed by the meeting of the lateral planes and the terminal planes; or we say, they are the edges of the lateral faces of the table, so that there are eight lateral edges in a four-sided table, &c. *Terminal edges* are formed by the junction of lateral and terminal planes, as in the prism and pyramid; or they are those that surround the terminal planes in the prism or the base of the pyramid: they are also formed by the junction of two terminal planes, as in the table.†
3. *Solid angles.* The point in which three or more planes meet, is called a *solid angle.*

II. *The Varieties or Kinds of the Fundamental Figure.*

Werner admits seven fundamental figures, viz. *icosahedron*, *dodecahedron*, *hexahedron*, *prism*, *pyramid*, *table*, and *lens*

1. *Icosahedron* is a solid having twenty equilateral triangular planes, that meet together under nearly equal obtuse angles; and of twelve solid angles, so that there are always five planes to form an angle. Fig. 1. Plate CCCXCVI. It is rare. Example, Iron-pyrites.
2. *Dodecahedron* has twelve regular pentagonal planes that meet under equal obtuse angles; and of twenty solid angles. Fig. 2. It occurs but seldom. Example, Iron-pyrites.
3. *Hexahedron* is a solid, having six square planes and eight solid angles. It includes the cube, Fig. 3. and the rhomboid, Fig. 4. which is sometimes considered as a double three-sided pyramid, in which the lateral planes of the one are set on the lateral edges of the other. It is very frequent. Example, Calcareous-spar.
4. *Prism* has an indeterminate number of quadrangular lateral planes, terminated by two equal terminal planes, parallel to each other, and having as many sides as the prism has lateral planes, Fig. 5. This is the most frequent of the fundamental figures. Example, Calcareous-spar.
5. *Pyramid* has an indeterminate number of triangular lateral planes converging to a point, and a base possessing as many sides as the figure has lateral planes. Fig. 12. The terminal point is called the *summit* or

* When the faces are very small, they are named *facets*. † The terminal edges in the Table are those that measure its thickness

apex, and the flat part the *base*. It occurs very often. Example, Calcareous-spar.

6. *Table* has two equal and lateral planes, which are very large in comparison of the others, and which are bounded by an indeterminate number of small four-sided terminal planes. Fig. 15. It is but a very short prism. It is proper to observe, that the parts of the table are not denominated as those in the prism, but inversely, the lateral planes of the table corresponding to the terminal planes of the prism, and the terminal planes of the table to the lateral planes of the prism. It does not occur very often. Example, Heavy-spar.
7. *Lens* has two curved faces or planes, Figs. 19. and 20. It occurs but seldom. Example, Sparry-iron.

III. *The differences of each Fundamental Figure in particular.*

Here we have to determine, 1. *The Simplicity.* 2. *Number of Planes.* 3. *Proportional size of the planes to one another.* 4. *Direction of the planes.* 5 *Angles under which the planes meet.* 6. *Plenitude or fulness of the crystals.*

1. *Simplicity.*

With respect to simplicity, the fundamental figures are either *simple* or *double.* This distinction, however, is confined to the pyramid, as the other six kinds of primitive figures occur simple only. Fig. 12. is a simple pyramid; and Fig. 13. a double pyramid.

The simple figure is also distinguished, in regard of its position, into *erect* or *inverted*, according as it adheres by its base or its summit. The inverted has hitherto occurred only in calcareous spar, and is very rare.

In the double figure, we have to attend to the placing of the lateral planes; thus, the lateral planes of the one pyramid are placed either *straight* or *oblique* on the lateral planes of the other pyramid. In Fig. 13. they are placed straight; and in Fig. 14. they are placed obliquely; or the lateral planes of the one pyramid are set either on the lateral edges, as in Fig. 35. or on the lateral planes of the other, as in Fig. 13.

2. *Number of Planes.*

The number of planes in the icosahedron, dodecahedron, hexahedron, and lens, is always determinate, but in the prism, pyramid, and table, is indeterminate. In the prism and pyramid, it is only the lateral planes that vary in number, but in the table it is the terminal planes.

The *prism* occurs with three, four, six, eight, nine, and twelve lateral planes. The trihedral, or three-sided, occurs in schorl and tourmaline. The four-sided, or tetrahedral prism, Fig. 5. occurs very often; we have examples of it in felspar, zeolite, zircon, and heavy-spar. The six-sided, or hexahedral prism, Fig. 8. occurs very often, and is the most common prismatic crystallization; quartz, emerald, beryl, calcareous spar, heavy spar, and actynolite, afford examples of it. The octahedral, or eight-sided prism, is rare; it occurs in augite and topaz. The nine and twelve-sided prisms are merely varieties of the preceding figures; the first is formed by the bevelling of the lateral edges of the trihedral prism, the other by the truncation of the lateral edges of the six-sided prism. Beryl affords an example of the twelve-sided, and tourmaline of the nine-sided prism.

The *pyramid* occurs with three, four, six, and eight sides. The three-sided pyramid, Fig. 9. is either single or double; of the single we have examples in grey copper ore, spinel, copper pyrites, and many other minerals. Examples of the second occur in calcareous spar, as in Fig. 10. The four-sided pyramid is the most common, and is always double, Fig. 11.; when it appears single, the one half is either hid in part, or altogether in the matrix; diamond, zircon, and fluor spar, are examples. The six-sided, or hexahedral pyramid, occurs single, as in Fig. 12. and double, as in Fig. 13. Examples of it occur in sapphire and calcareous spar, red silver, white lead spar, quartz, and amethyst. The eight-sided is always double, and acuminated on both extremities by four planes, as in Fig. 35. Examples of it occur in leucite, garnet, and silver glance, or sulphuretted silver.

The table has four, six, or eight terminal planes. The *three*-sided tables are mere varieties of some of the other figures. The four-sided table, Fig. 15. occurs frequently, as in heavy spar, white antimony, and yellow lead spar. The six-sided table, Fig. 17. occurs still more frequently: we have examples of it in mica, calcareous spar, heavy spar, and native gold. The eight-sided table occurs in heavy spar, and yellow lead spar.

3. *Proportional Size of the Planes to one another.*

This character is not of much importance. The planes are either equilateral or unequal; where they are unequal, they are either indeterminately or determinately unequal. The determinately unequal planes are alternately broad and narrow; with two opposite planes broader; with two opposite planes narrower.

In the hexahedron, dodecahedron, and icosahedron, the planes are alike; when any dissimilarity occurs, it is merely accidental, and is therefore indeterminately unequal. The three-sided prism shews only slight indeterminate inequalities. The four-sided prism is not always equilateral; sometimes two opposite planes are broader than the others, when the prism is said to be broad, as in zeolite. The six-sided prism is almost always equilateral; its varieties are generally accidental, excepting the following, which are somewhat characteristic. 1. The two opposite lateral planes broader than the others, as in actynolite and heavy spar. 2. The planes alternately broader and narrower, as in calcareous spar. The eight and nine sided prisms afford only accidental or indeterminate varieties, as augate, topaz, and tourmaline.

In the pyramid, sometimes the two opposite planes are larger than the others, when it is said to be broad.

The four-sided table is usually equilateral; it has sometimes, however, two opposite lateral planes longer than the others, as in Fig. 16. The six-sided table is sometimes unequilateral, or two opposite planes are larger than the others, as in Fig. 18.; and the eight-sided table is usually longish.

4. *The Direction of the Planes or Faces.*

The direction of the planes or faces is either *Rectilinear* or *Curvilinear.*

Rectilinear is the most common, and is the case with almost all the fundamental figures.

Curvilinear planes* differ partly by the position of the curvature, which is either *concave*, as in fluor-spar; *convex*, as in diamond; *concavo-convex*, as in sparry ironstone; *saddle-shaped*, as in the lens; they differ also by the *shape*, being either *spherical*, as in brown spar; *cylindrical*, in which the convexity is either parallel with the sides, as in iron pyrites, or parallel with the diagonal, as in fluor spar; and *conical*, as in gypsum, and probably also in galena or lead glance.

5. *Angles under which the Planes meet.*

The size of the angles formed by the meeting of the planes is determined either by means of an instrument named *Goniometer*, or angle-measurer, or simply by ocular inspection. Several different kinds of goniometer have been contrived. They are described in the article Crystallography.

The other mode of ascertaining the magnitude of crystals, namely, by ocular inspection, without the aid of the goniometer, is that practised by Werner. In this way he determined the whole of the species in the system. The following are the terms used by him when describing the angles and edges of crystals.

Several different kinds of angles occur in the fundamental figures: these are, the *angles of the lateral edges*, *angles of the terminal edges*, and *the summit angles*.

1. The angles formed by the meeting of the lateral planes, are named the *angles of the lateral edges*, or, to shorten the description, simply *lateral edges*. Thus we say acute and obtuse lateral edges, in place of acute and obtuse angles formed by the meeting of the lateral planes. The lateral edges are either *equiangular* or *unequiangular*. In the icosahedron, all the edges are *equiangular*. In the dodecahedron, the edges are *equiangular*. The hexahedron is either *equiangular* and also *rectangular*, or *unequiangular* and *oblique angular*. The rectangular hexahedron is named *cube*; the oblique angular, *rhomboid*. In the prism, the lateral edges are either *equiangular* or *unequiangular*. The four-sided prism, with unequiangular lateral edges, is denominated an oblique four-sided prism, Fig. 6. Plate CCCXCVI. In the pyramid, the lateral edges are generally equiangular; seldom unequiangular. The same is the case with the table; when the edges are unequiangular, we say the terminal planes are set obliquely on the lateral planes.
2. The *terminal edges* are formed by the meeting of lateral and terminal planes. In the prism they are generally equiangular, as in Fig. 6. Plate CCCXCVI. and sometimes unequiangular, when we say that the terminal planes are set obliquely on the lateral planes, as in Fig. 7. Plate CCCXCVI. They are always equiangular in the pyramid. In the table they are as in the lateral edges of the prism.
3. The *summit angle*. It occurs only in the pyramid. It is measured from plane to plane, or from plane to edge. Werner determines it in degrees in the following manner.

a. Extremely acute, is from 1° to 30°.
b. Very acute, from 30° to 50°. Example, Sapphire.
c. Acute, from 50° to 70°. Example, Calcareous spar.
d. Rather acute, from 70° to 90°. Example, Quartz.
e. Rectangular, 90°. Example, Zircon.
f. Rather obtuse, or rather flat, from 90° to 110°. Example, Honey-stone.
g. Obtuse or flat, from 110° to 130°. Example, Calcareous spar.
h. Very obtuse, or very flat, from 130° to 150°. Example, Tourmaline.
i. Extremely obtuse, or extremely flat, from 150° to 180°.

6. *Plenitude or Fulness of the Crystals.*

A. *Full*, as in almost all crystals.
B. *Excavated at the extremities*, as in green-lead ore.
C. *Hollow*. Olive green-coloured calcareous spar from Schemnitz, in Hungary, occurs in acute hollow three-sided pyramids.

II. The Alterations on the Fundamental Figure.

These are produced by, 1. *Truncation*; 2. *Bevelment*; 3. *Acumination*; and, 4. *Division of the Planes*.

1. *Truncation.*

When we observe on a fundamental figure, in place of an edge or angle, a small plane, such a plane is denominated a Truncation.

These new planes are named *Truncated Planes*, and the edges which they form with the other planes *Truncating Edges*.

We have here to observe what relates to the *situation*, *magnitude*, the *setting on* or *position*, and the *direction* of the *truncation*.

a. In regard to the *situation* of the truncation, it is either on the edges or on the angles, and sometimes a few, sometimes all the angles and edges of the figure are truncated. Fig. 21. a cube truncated on the angles; and Fig. 22. a cube truncated on the edges.
b. In regard to the *magnitude* of the truncation, it is either *deep* or *slight*, according as more or less of the fundamental figure is wanting; and consequently the truncating planes are proportionally greater or smaller.
c. The planes are *set on* either straight or oblique. They are said to be *set on straight*, when they are equally inclined on all the adjacent planes; and *set on obliquely*, when they are not equally inclined on the adjacent planes.
d. The truncating planes, in regard to their *direction*, are either *straight* or *curved*. In the latter case, we also say that the edge or angle is *rounded off*.

2. *Bevelment or Cuneature.*

When the edges, terminal planes, or angles, of a fundamental figure are so altered, that we observe in their place two smaller converging planes, terminating in an edge, they are said to be bevelled. These two newer or additional planes are named *bevelling planes*; and the edge formed by their meeting, the *bevelling edge*. We have here, again, to observe the *situation*, *magnitude*, *angle*, *uniformity*, and *setting on* of the bevelment.

a. In regard to *situation*, the bevelment is generally on the edges, sometimes on the terminal planes, and seldomer on the angles. Fig. 23. is a cube bevelled on the edges; Fig. 24. a three-sided prism, bevelled on the lateral edges; Fig. 25. a four-sided prism, bevelled on the terminal planes. the bevelling planes set on the lateral edges; Fig. 26. a table bevelled on

* It is not geometrically correct to speak of curved planes; yet, as the term plane is more generally used by mineralogists than face or side, we have not thought it necessary to make any alteration.

the terminal planes; and Fig. 27. an octahedron bevelled on all the angles.

b. In regard to *magnitude* of the bevelment, it is either *deep* or *slight*, according as more or less of the fundamental figure is wanting.

c. In regard to the *angle*, the bevelment is *obtuse* or *flat*, or *rectangular* or *acute angular*.

d. The bevelment, in regard to *uniformity*, is either *unbroken*, when it extends in one direction; or *broken*, when each bevelling plane consists of several planes; sometimes of two planes, when it is said to be *once broken*; and sometimes of three planes, when it is said to be *twice broken*.

e. In regard to the *setting on*, we have to attend to the *position* and the *direction* of the bevelling planes.

a. In regard to the *position*, the bevelling planes are either on planes or on edges.

b. The *direction* varies only when the bevelling planes are set on the terminal planes. It is said to be *set on straight*, when the bevelling edge is at right angles to the axis of the crystal; and *set on oblique*, when it forms an oblique angle with the axis of the crystal.

3. *Acumination.*

A fundamental figure is said to be acuminated when, in place of its angles or terminal planes, we find at least three additional planes which converge into a point, and sometimes, but more rarely, terminate in an edge.

We have here to observe the parts of the acumination; these are,

The acuminating planes.

The edges of the acumination, which are,

The proper acuminating edges, those formed by the meeting of acuminating planes.

The edges which the acuminating planes make with the lateral planes of the fundamental figure.

The terminal edges of the acumination, which are formed by the terminating of the acuminating planes in an edge or line.

The angles of the acumination; which are,

The angles which the acuminating planes form with the lateral planes; and,

The summit angle.

We have to determine in the acumination, its *situation*; the *number of its planes*; *proportional magnitude of the planes among themselves*; the *setting on* or *application of the planes*; the *angles of the acumination*; its *magnitude* and *termination*.

a. *Its situation* is either on angles, as in Fig. 28. and 29. or on terminal planes, as in Fig. 30.

b. *The number of planes* is three, as in Fig. 33. and 34.; four, as in Fig. 30.; six, as in Fig. 31.; or eight, as in Fig. 35

c. *The proportional magnitude of the planes among themselves*, is a character of but little importance. They are generally determinately unequal, as in heavy-spar; or undeterminately unequal, as in rock-crystal.

d. *The setting on* or *application of the planes* refers to their position on edges, as in Fig. 29. 32 34. or planes, as in Fig. 28. 30 31. and 33. When the planes of an acumination are not set on all the edges or planes of the fundamental figure, but only on the alternate planes or edges, it is said to be *set on alternately*, as in Fig 33. and 34 and when the acuminating planes on both extremities of the fundamental figure are set on the same planes or edges, it is said to be *conformable*, (rechtsinnig,) as in Fig. 31.; but when the planes on opposite ends of the figure are set on different planes or edges, it is said to be *unconformable*, as in Fig. 33. and 34. The same expressions are applied to alternate Truncations.

e. The *angle of the acumination*, or the *summit angle*, is either obtuse or flat, as in garnet; rectangular, as in zircon; or acute, as in calcareous-spar.

f. The *magnitude*; according to which crystals are *deeply acuminated*, as in cubic crystals of fluor-spar, whose angles are acuminated with six planes; *slightly acuminated*, as in copper-pyrites or grey copper.

g. The *termination*, according as the acumination ends in a point, which is the usual mode, or in a line or edge, which is less frequent.

In order to form a more distinct idea of truncation, bevelment and acumination, let us take a cube, prism, pyramid, or any other perfect fundamental figure represented in wood, and cut off each of the edges or angles at one stroke, so that in its stead a plane shall appear; this will be truncation. But if the terminal planes, the edges, or the angles of any of these fundamental figures, be cut off with two converging strokes, the one from this side, the other from that, so that two planes arise, which, terminating in a line, shall present an edge; this will be bevelling. And if the terminal planes or the angles be cut off at several strokes, all converging together, so that more than two planes arise, commonly terminating in a point, we shall obtain acumination.

4. *The Division of the planes.*

Here the number of the planes of the fundamental figure is neither increased, nor is their figure changed, as is the case with all the preceding alterations, but each plane is divided into a greater or lesser number of smaller planes that meet together under very obtuse angles.

The number of compartments into which a plane is divided, is two, three, four, and six.

The dividing edges run either parallel to the diagonal, or from the centre of the plane of the fundamental figure towards the angles, or towards the middle of the edges and the angles at the same time. Of the first we have an example in the dodecahedral garnet; and of the second in grey copper-ore and diamond.

5. *Multiplied Alterations.*

The various alterations of the fundamental figures just enumerated occur singly, or several together, in the same fundamental figure. In the latter case, they are placed either beside each other, when they are said to be *co-ordinate*, or on one another, when they are said to be *superimposed*. The alterations are considered to be co-ordinate, when they occur in *different places* of the same fundamental figure; of this we have an example in fluor-spar, when the cube is bevelled on the edges, and truncated on the angles. They are named *superimposed*, when they occur in the *same part* of the fundamental figure, and when the first alteration is modified by a second, as in a prism which is bevelled on the terminal planes, and truncated on the bevelling edges. Sometimes, as in topaz, three or more superimposed alterations occur together in the same figure. Crystallizations frequently occur which are so modified, that they may be described in different ways, and referred sometimes to one, sometimes to another fundamental figure. This gives rise to two modes of description, viz. the *representative* and the *derivative*. If a crystal is described as it appears to the eye at first view, without any reference to its relation to other crystallizations of the same mineral, it is said to be described representatively. But if in the description we attend to its relations with the other crystals of the same mineral, and also to its derivation from these, it is described derivatively. Thus, in calcareous spar, we meet with forms, which, if described derivatively, would be considered as very low six-sided prisms, acuminated on both extremities with three planes, the planes set on the alternate lateral planes; and the summits of the acuminations so deeply truncated, that they touch the unaltered lateral planes in a line. But on a first view this figure presents nothing prismatic; and if ignorant of its origin from the prism already mentioned, we would rather consider it as a flat, double, three-sided pyramid, in which the lateral planes of the one are set on the lateral planes of the other, and the summits, and the angles on the common basis, deeply truncated. In the same manner, many very broad prisms, as in rock-crystal, at first sight appear like tables, but must be considered as prisms, on account of their derivation and other relations.

The derivative mode is the most interesting and useful, and is that which ought to be followed whenever it is possible.

In those cases, however, where the choice of the fundamental figure is optional, and when it is not determined by tracing it from other crystallizations, we give the preference to that figure which enables us to describe the crystal with the greatest facility and accuracy, and in the shortest manner. It is sometimes advantageous, and also facilitates our conception of the crystal, when we unite together in our description both the modes, using the derivative as the principal one. Thus many varieties of the cube and the rhomboid are more clearly expressed, when we describe them as double three-sided pyramids, in which the lateral planes of the one are set on the lateral edges of the other.

The different modes of describing crystals depend on the transitions that so often occur between them, by which one figure, owing to a succession of modifications, gradually passes into the other. Thus the cube, by the truncation of its angles, passes into the perfect octahedron. At first, the truncating planes on the angles of the cube are small, but become gradually larger and larger until they touch each other, when the crystal exhibits a form intermediate between that of the cube and the octahedron. If the truncating planes still increase in size, they become larger than those of the cube, and are now the principal planes of the figure, while those of the cube are alternating planes, and the whole represents an octahedron truncated on the angles. If the original planes of the cube, which now form truncating planes in the angles of the octahedron, become smaller and smaller, and at length entirely disappear, the perfect octahedron is produced.

The modifications that give rise to these transitions are the following.

1. *Alterations taking place in the proportional magnitude of the planes between themselves.*

Some planes increase in size, while others diminish, and thus one figure is changed into another. When the alternate lateral planes of the octahedron become larger, while the others diminish, a tetrahedron is formed, or the octahedron passes into the tetrahedron.

2. *Alterations in the angles under which the planes meet.* Thus the common dodecahedron, by the increasing obtuseness of its angles, at length passes into the cube.
3. The *convexity* of the faces of the crystals, which is sometimes occasioned by the division of the planes.
4. *By the newer or alternating planes becoming gradually larger at the expense of the original planes, which are at length totally obliterated.*

These changes are produced either by truncation, bevelment, or acumination; the transition of the cube into the octahedron, is an example of the first: the transition of the octahedron into the icosahedron, by the bevelment of the angles of the octahedron, of the second; and the third is exemplified by the transition of the tetrahedron into the rhomboidal or garnet-dodecahedron, by the acumination of each of the angles of the tetrahedron by three planes.

5. *By the aggregation of crystals.* Thus six-sided tables heaped on one another form six-sided prisms.

All the crystals that lie between two principal crystals, and form the transition of the one into the other, constitute what is called a *transition-suite.* These vary in extent, and sometimes they form circles, so that the last member of the suite passes into the first, or they form a straight line, and diverge into numerous branches.

Those mineral species that occur crystallized, are generally characterised by a particular suite of crystals, which does not occur in the other species. There are, however, mineral species very different from each other in their external characters, in which we meet with the same suite of crystals; and still more frequently do we meet with species that exhibit not the whole suite of crystals of another species, but a greater or smaller portion of it. Thus there is an extensive suite of crystals which extends from the icosahedron, through the dodecahedron, the cube, and the octahedron, into the tetrahedron, part of which we sometimes meet with in mineral species, but never the whole, only a larger or smaller portion of it.

That member of the suite of crystals of a mineral species, from which all the others originate or proceed, is named the *Fundamental Crystallization.* In those suites of crystals which form circles, it is often optional which of the figures we assume as the fundamental one; and in those which are disposed in lines, it is sometimes of little importance at which end we begin our description. Still we always select that crystallization which occurs the most frequently, and the most distinct in the species, and derive all the others from it.

In mineral species the crystals never appear isolated, but form a kind of progression, and pass gradually into each other. It follows from this important and highly interesting fact, that when a few crystals of a species are known, probably all the intermediate members of the series, which can be easily pointed out by crystallography, and which have not been found, may be expected to exist in nature, because the cause which produced the one part of the series may also have formed the others.

C. The Magnitude of Crystals.

This character is useful, not only in the description of varieties, but also in that of species, because in each mineral species the crystals appear to have a determinate range of magnitude. We have here to attend to the *absolute magnitude*, and also to the *relative magnitude*, of crystals.

Crystals, in regard to their *Absolute magnitude*, are divided into

α. *Uncommonly large*, when the crystal is two feet and upwards in length. The expression intimates that it is rare. Example, rock crystal.

β. *Very large*, from two feet to six inches in length. Examples, rock crystal, quartz, beryl, calcareous-spar, and felspar.

γ. *Large*, from six inches to two inches in length. It is a very frequent size. Examples, lead-glance, garnet, rock crystal, &c.

δ. *Middle-sized*, from two inches to half an inch. Examples of this magnitude are common, we shall only mention galena or lead-glance, iron pyrites, fluor-spar, calcareous-spar, and garnet.

ε. *Small*, from half an inch to the eighth of an inch. Examples, fluor-spar, calcareous-spar, &c.

ζ. *Very small*, from the eighth of an inch in length, until it is so minute as scarcely to be visible to the naked eye. Examples, native silver, grey copper-ore, spinel, &c.

η. *Microscopic*. When crystallized, but the form no longer distinguishable by the naked eye. Examples, gold, galena or lead-glance, &c.

In determining the *Relative magnitude* of crystals, we use the following terms.

α. In the prism.
- *aa*. For the length.
  - *Short* or *low*.
  - *Long* or *high*.
- *bb*. For the breadth and thickness.
  - *Broad*, when the breadth is greater than the thickness.
  - *Acicular* or *needle-shaped*, when the prisms are so thin that the planes are seen with difficulty.
  - *Capillary*, when the planes of the crystals are no longer visible.

β. In the pyramid.
- *aa*. For the length.
  - *Short* or *low*.
  - *Long* or *high*.
- *bb*. For breadth and thickness.
  - *Broad*.
  - *Lance-shaped*, allied to acicular.

γ. In the table.
- *aa*. For the length and breadth.
  - *Longish*, when one dimension of the lateral planes is greater than the others.
- *bb*. For the thickness.
  - *Thick* and *thin*.

δ. Crystals in which all the dimensions are nearly alike, are named *tessular*.

D. The Attachment of Crystals.

Werner understands by *attachment*, the connection of single crystals with massive minerals, and the aggregation of crystals together. According to the tabular view, the first distinction is into

A. *Solitary;* and this again into *loose*, *imbedded*, and *superimposed*.

α. *Loose*. Crystals are said to be loose, when they are not connected with any other mineral.

β. *Imbedded*. Crystals are said to be imbedded when they are completely enclosed in another mineral. They are crystallized on all sides, or are said to be all around crystallized, and must therefore have been formed at the same time with the mineral in which they are imbedded. We cannot conceive them to have been of anterior origin to the basis in which they are contained: for, on this supposition, we must conceive them to have remained suspended in space until the basis was formed around them. Nor can we admit them to be of posterior origin, because the crystals have impressed their form on the basis, and portions of the basis are sometimes contained in the crystals, and the crystals at their lines of junction, are occasionally intermixed with the basis. Examples of this we have in garnets imbedded in serpentine, or garnets in mica-slate.

γ. *Superimposed*. When crystals rest upon the surface of another mineral, and are firmly attached to it, they are said to be superimposed. No regular planes occur at their point of attachment; on the contrary, they take the impression of the kind of surface on which they rest. Hence it would appear, that probably they are often of posterior origin to the basis on which they rest.

The second distinction is into

B. *Aggregated*. Here there are two distinctions.

a. Where a determinate number of *crystals grow together in a determinate manner, and these differ*,

1. *With respect to number*.
   - i. *Pair wise* (twin crystals.)
   - ii. *Three together* (triple crystals.)
   - iii. *Four together* (quadruple crystals.)
2. *With regard to the manner of their intersection*.
   - i. *Penetrating one another*.
   - ii. *Intersecting one another*.
   - iii. *Adhering to one another*.

Twin crystals are formed by two crystals penetrating, intersecting, or adhering to one another. Of the *first* we have an example in felspar, where they penetrate one another in the direction of their thickness; in gypsum, where they penetrate one another in the direction of their breadth; and in calcareous-spar, where they penetrate one another in the direction of their length. Of the *second* we have an example in cross-stone, where the crystals intersect each other, and form a kind of cross, and have a common axis; and of the *third* in spinel, where the crystals adhere only by some of their planes.

Triple crystals, occur in spinel and calcareous-spar.

Quadruple crystals, occur rarely, as in tin-stone.

b. *Where there are many crystals together, but merely simply aggregated;* and these are either, 1. *On one another;* 2. *Side by side*, or adhering laterally to one another; and 3. *Promiscuous*.

The *first* occurs principally in tessular crystals, as in galena or lead-glance and fluor-spar. The *second* occurs in amethyst, where the pyramids or prisms are parallel among themselves. The *third* occurs principally in long and broad figures, as in tables and prisms. We have examples of it in grey ore of antimony, where very long and nearly needle-shaped crystals cross one another in different directions; also in tabular crystals, and this kind of tabular aggregation has much resemblance to the cellular external shape.

c. Where there are many crystals together, but doubly aggregated.

This kind of aggregation is distinguished from the foregoing by its forming groupes that exhibit shapes resembling bodies in common life.

i. *Scopiform* or *fascicular*. It is composed of a number of thin prismatic crystals, diverging from their point of attachment, and thus forming a kind of fasciculus or bundle. Examples, calcareous-spar and zeolite.

ii. *Manipular sheaf-like*. Consists of a number of crystals that diverge towards both ends, and are narrower in the middle, thus resembling a sheaf. It occurs in prismatic and tabular crystals. Examples, zeolite, calcareous-spar, and prehnite.

iii. *Columnar*. Consists of very long needle-shaped prisms, many of which are connected together in the direction of their length; and these columnar groupes sometimes cross one another in different directions. Examples, columnar heavy spar, and white-lead-spar.

iv. *Pyramidal*, is composed of many long prismatic crystals that are parallel to one another, but of which those in the middle are the highest, and the others decline on all sides, from the central one. Example, calcareous-spar.

v. *Bud-like*, is composed of low (generally) six sided pyramids, one of which is usually situated in the middle, and is surrounded by a number of others, whose extremities are directed towards one another. Here also many groupes occur together. Example, quartz.

vi. *Amygdaloidal*, is formed by tables disposed around each other, in such a manner as to form an amygdaloidal shape. Example, straight lamellar heavy spar.

vii. *Rose-like*, is composed of very thin six-sided tables, which are repeatedly curved, and so connected together that the groupe resembles a blown rose. It occurs in the variety of calcareous-spar called *rose-spar*, from Joachimsthal.

viii. *Globular*. Is composed of tables or cubes aggregated into a globular shape. Examples, iron pyrites, and curved lamellar heavy spar.

ix. *In rows*. When many crystals are superimposed on each other, in a straight direction, like the pearls in a necklace, they are said to be aggregated in rows. The flat three-sided pyramids of calcareous-spar, and the octahedrons of silver-glance or sulphuretted silver, afford examples of this kind of aggregation.

x. *Scalarwise*, in which many tessular crystals are arranged like steps of a stair. Example, cubes of corneous silver.

IV. *Extraneous External Shape.*

Extraneous external shapes of minerals are those derived from organic bodies. They are also named *Petrifactions*, and less properly *Fossils*. The particular study of these interesting forms belongs to geognosy, as the oryctognost views them only in a general way. In general, they are arranged in the order in which the species are described in the natural history of organic bodies, and are divided into petrifactions from the animal kingdom, and into those from the vegetable kingdom.*

A. Petrifactions from the Animal Kingdom.

a. Quadrupeds. The fossil remains of quadrupeds are generally found but little altered, and in single pieces, as bones, teeth, and horns; seldom in complete skeletons. The greater number of species found in this state appear to be extinct.†

b. Birds. The remains of birds, which are usually single bones, feet, claws, and bills, are very rare; they have been found in the vicinity of Mont Martre, near Paris, and in the limestone of Æningen and Pappenheim.

c. Amphibious Animals. Fossil remains of tortoises and crocodiles have been met with in different parts of Europe. Fossil tortoises occur in the Isle of Shepey in the Medway; and fossil remains of animals allied to the crocodile, are met with in the neighbourhood of Bath, in the cliffs on the Dorsetshire coast, and also on the coast of Yorkshire.

d. Fishes. Of these we find petrified, either the entire fish, skeletons, vertebræ, or teeth. Of the entire fish, instances have been observed in the copper or marl slate of the county of Mansfeld; and also in Oxfordshire, Gloucestershire, Leicestershire, Lincolnshire, Dorsetshire, and Kent;‡ of the skeletons in the limestone of Pappenheim; of the vertebræ in Shepey; of the teeth, particularly those of the shark, considerable quantities in the Island of Malta, and also in Kent and Isle of Shepey.

e. Insects. These are very rare. The only well authenticated instances of petrified fresh water insects, are the larvæ of libellulæ, found in the limestone of Pappenheim. Of sea insects, a very considerable variety have been discovered. Of the genus cancer, several distinct species have been found in the Isle of Shepey, in the Medway.

Insects inclosed in amber are not to be regarded as petrifactions, because they are dead bodies nearly unaltered.

f. Shells. Many genera of fossil shells are enumerated by authors. It is sufficient for our present purpose to remark, that these fossil remains are uncommonly numerous, and are for the most part of species which have never been found in a living state.

* In describing petrifactions, with the view of a complete history of the species, a more regular and comprehensive arrangement ought to be followed than that usually employed by naturalists. In a paper which Professor Jameson read before the Wernerian Society some years ago, he proposed and adopted the following arrangement, in describing a petrifaction from Sicily. 1. Description of the external aspect and internal structure. 2. Chemical characters, and chemical composition. 3. Geognostic situation. 4. Geographic situation. 5. Uses. 6. History, under which head he includes all that is known of the first discovery of the petrifaction, the names it may have had at different times, the different figures and descriptions of it published by authors, and other information of a miscellaneous nature.

† It may be remarked, that the fossil remains of the human species rarely occur; the only well-authenticated example of this kind being the human skeleton imbedded in an alluvial calcareous mass brought from Guadaloupe by Sir Alexander Cochrane, and now presented to the British Museum by Lord Melville; nor should the rarity of their occurrence excite our wonder, when it is recollected that human bones are looser in their texture, and more cellular than those of quadrupeds, and therefore much more liable to decomposition.

‡ Parkinson's *Organic Remains*, vol. iii. p. 249.

g. Crustaceous Animals. Of these, the most remarkable and abundant are the Echinites and Asterites.

h. Corals. Many different fossil genera and species of these bodies have been figured and described by naturalists, under the names Madreporites, Milleporites, Fungites, &c.

B. Petrifactions from the Vegetable Kingdom.

These are,

a. Impressions of plants and leaves. These occur very frequently, and appear to characterize particular formations. Thus, the impressions and casts of reeds and ferns appear to occur most frequently in the bituminous shale and slate-clay of the coal formation. Petrifactions of seeds and fruits also occur in sandstone and other rocks.

b. Transmuted wood, or *petrified wood.* It occurs in the form of trunks, branches, or roots. The wood is either petrified with an earthy mineral, as in wood-stone and wood-opal; with a metalliferous mineral, as in pyritical wood; or it is bituminous, as in the different kinds of brown-coal.*

II. *The External Surface.*

The external surface of minerals is either smooth, or more or less uneven. When the inequalities become so great as to affect the shape, they are no longer considered as characterizing a variety of surface, but as a variety of external form.

The following are the varieties of this character.

1. *Uneven.* This, of all the kinds of external surface, presents the greatest and most irregular elevations and depressions, yet they are not so considerable as to alter the external shape. Example, Surface of balls of calcedony.

2. *Granulated.* When the surface shews numerous small nearly similar roundish elevations, that appear like grains strewed over it, it is said to be granulated. It has a striking resemblance to shagreen.

3. *Rough.* This kind of surface is marked with small scarcely visible elevations, which we can hardly discover but by the feel. It has little or no lustre. Examples, Rolled pieces of common quartz and rock-crystal.

4. *Smooth.* Here there is no perceptible inequality, and the surface reflects more light than the preceding kinds of external surface. Examples, Fluor-spar, cubes of galena or lead-glance.

5. *Streaked.* This kind of surface is marked with line-like elevations. It is either *simply streaked* or *doubly streaked.*

A. *Simply streaked*, when the line-like elevations run but in one direction.

a. Longitudinally streaked. When the streaks are parallel with the length of the lateral planes. Example. Topaz.

b. Transversely streaked. When the streaks are parallel with the breadth of the lateral planes. Example, Rock-crystal.

c. Diagonally streaked. Where the streaks are parallel with the diagonal of the planes. We have an example of it in the garnet, where the streaks pass through the obtuse angle of the rhomboid.

d. Alternately streaked. When transverse and longitudinal streaks occur on alternate planes. Example, Cubic iron-pyrites.

B. *Doubly streaked*, when the streaks run in different directions. This is either

a. Plumiformly. When the streaks run obliquely towards a principal streak, like the disposition of the parts of a feather. We must be careful not to confound it with the plumose external shape. It occurs in the folia of Plumose native bismuth.

b. Reticularly. When the streaks either cross each other in a promiscuous manner, or under right angles, forming a kind of flat net-work. It occurs on the surface of silver-white cobalt.

6. *Drusy.* When a crystal is coated with a number of minute crystals of the same kind, so that the new surface acquires a scaly aspect, it is denominated drusy. Example, Common iron-pyrites.

III. *The External Lustre.*

Here we have to consider the *intensity* and the *sort* of lustre.

1. *The intensity of the lustre.* Of this there are five different degrees.

A. *Splendent.* A fossil is said to be splendent, when in full day-light (not in the sunshine) its lustre is visible at a great distance. The highest degree of this is termed *splecular splendent.* It generally occurs in minerals with a perfect foliated fracture. Example, Galena or lead-glance.

B. *Shining.* When a mineral at a distance reflects but a weak light, it is said to be shining. Example, Heavy spar.

C. *Glistening.* This degree of lustre is only observable when the mineral is near us, and at no greater distance than arm's length. Example, Porcelain jasper.

D. *Glimmering.* If the surface of a mineral, when held near to the eye in full and clear day-light, presents a very great number of small faintly shining points, it is said to be glimmering. In strong sunshine it exhibits a kind of play of colour. As an example of this degree of lustre, we may mention red hematite. It is divided into *metallic* and *non-metallic.*

E. *Dull.* When a mineral does not reflect any light, or is entirely destitute of lustre, it is said to be dull. Example, chalk.

2. *The sort of lustre.* Of the different sorts of lustre we cannot give any definition, but must rest satisfied with mentioning a few minerals which present these characters in the greatest perfection.

a. Metallic lustre, is always combined with opacity. It is divided into *perfect* and *imperfect.* The perfect occurs in native metals, the imperfect in tantalum ore.

b. Adamantine. Of this lustre there are two varieties, viz *metallic adamantine*, and *common adamantine.* White lead spar is an example of the first, and diamond of the second.

c. Pearly. Is divided into *common*, and *metallic-like.* Mica is an example of the first, and schiller spar of the second.

* The best English work on Petrifactions, is that of Mr. Parkinson, entitled "*Organic Remains of a Former World.*" It abounds in curious and important information, and is adorned and illustrated with numerous beautiful plates. Mr. Sowerby is publishing a useful work, entitled "*Mineral Conchology.*" And the valuable observations on Organic Remains, in the Transactions of the Geological Society of London, are further proofs of the general attention now bestowed on the natural history of petrifactions.

d. Resinous or *waxy*, as in pitchstone, yellow lead-spar, and tinstone crystals.

e. Vitreous or *glassy*, as in rock-crystal and topaz.

1. In determining the lustre of minerals, we ought to expose them to a strong light, but not to the direct rays of the sun. The specimens should not be handled, a practice too often followed, and which very soon alters the lustre, or adds a lustre to such as have none.

2. When different kinds of lustre occur in the same species, and pass into each other, a *lustre suite* is formed. The red silver affords an example of this. In some varieties the lustre is nearly perfect metallic; in others distinct adamantine; and other varieties are between metallic and adamantine; so that the whole forms a complete series or suite, where we cannot say where the one begins and the other ends.

II. THE ASPECT OF THE FRACTURE.

Here we have to observe the *lustre* of the fracture, the *fracture*, and the *shape of the fragments.*

IV. *The Lustre of the Fracture.*

The internal lustre, or the lustre of the fracture, presents the same varieties as the external lustre, and therefore requires no particular description.

V. *The Fracture.*

By fracture we understand the shape of those internal surfaces or planes of a mineral which are produced by breaking or splitting it. These surfaces are either continuous, when the fracture is said to be *compact*, or are composed of a number of line-like or foliated parts, termed *distinct concretions*, when the fracture is named *split* or *divided.*

A. *Compact Fracture.* There are six different kinds of compact fracture, viz. *splintery*, *even*, *conchoidal*, *uneven*, *earthy*, and *hackly*.

a. Splintery. When, on a nearly even surface, small wedge-shaped or scaly parts are to be observed, which adhere by their thicker ends, and allow light to pass through, we say that it is splintery. It sometimes passes into even. Examples, Ironstone and quartz.

b. Even, is that kind of fracture-surface which shows the fewest inequalities, and these inequalities are flat, and their boundaries never sharply marked; on the contrary, they run into each other imperceptibly. Minerals possessing this kind of fracture have generally a low degree of lustre and of transparency. It occurs in chrysoprase, calcedony, compact galena or lead-glance, compact red ironstone, and compact brown ironstone. It passes into large conchoidal and into splintery. Example, Lydian stone.

c. Conchoidal, is composed of concave and convex roundish elevations and depressions, which are more or less regular: when regular, they are accompanied with concentric ridges, as in many shells, and hence present a conchoidal appearance. Example, obsidian.

d. Uneven. This kind of fracture shows the most considerable elevations and depressions, and the elevations are usually angular and irregular. These elevations are denominated the *grain;* and, according to the size of the grain, the fracture is named *coarse-grained*, as in copper-pyrites; *small-grained*, as in copper-nickel; or *fine-grained*, as in arsenical pyrites.

This kind of fracture frequently occurs in opaque minerals having some lustre, and is more frequent in metallic minerals. It passes into small and imperfect conchoidal, and also into earthy.

e. Earthy. When the fracture surface shows a great number of very small elevations and depressions, which make it appear rough, it is called earthy. It is always associated with complete opacity and want of lustre, which latter character distinguishes it from the fine grained uneven fracture. It is peculiar to earthy minerals. It is distinguished into Coarse earthy and Fine earthy. It passes sometimes into even, and sometimes into uneven. Examples, Chalk, and clay ironstone.

f. Hackly. When the fracture surface consists of numerous small slightly bent sharp inequalities, which are sometimes only discoverable to the feel, it is said to be hackly. It occurs only in native malleable metals, and is, consequently, accompanied with metallic lustre and opacity. Examples, Native copper, and native silver.

These different kinds of compact fracture often run into each other, and frequently several occur together; in the latter case, the most prevalent fracture is that which is to be taken as the characteristic one.

B. *Split fracture.** Under this head we include what is called by some mineralogists, the *Structure of Minerals.*

Three different kinds of split fracture are enumerated by authors, viz. the *fibrous*, *radiated*, and *foliated.*

C. *Fibrous fracture.* In this kind of fracture the distinct concretions of which it is composed are so narrow, that the only magnitude which can be readily determined, by the naked eye, is the length; hence it is to be considered as composed of line-like parts. It is never dull; on the contrary, it is generally glimmering or glistening, seldom shining, and never splendent. It sometimes occurs in transparent minerals, but oftener in those which are only translucent, or even nearly opaque. The minerals in which it occurs are sometimes crystallized in capillary crystals. In the fibrous fracture we have to attend to the *thickness*, the *direction*, and the *position* of the fibres.

a. Thickness of the fibres.

α. Coarse fibrous, when the fibres are of considerable thickness, as in common fibrous quartz, common asbestus, and fibrous gypsum.

β. Delicate fibrous, when the fibres are narrower than in the preceding variety, and occasionally so delicate, as to be scarcely visible to the naked eye. Examples of delicate fibrous fracture occur in red hematite, and fibrous malachite; and of extremely

* This is the *gespaltenen Bruch* of the Germans; which I have translated *split fracture*, probably not a very appropriate translation, but I do not remember any less objectionable. The fibrous and radiated fractures are, more properly speaking, varieties of distinct concretions, and in this latter acceptation they are generally employed in the description of the species of this article.

delicate fibrous fracture, in calc-sinter and amianthus.

The coarse fibrous fracture is the link which connects the fibrous with the radiated fracture.

b. The *direction* of the fibres.

α. *Straight fibrous*, as in red hematite and fibrous malachite.

β. *Curved fibrous*, as in asbestus and fibrous gypsum.

c. The *position*.

α. *Parallel fibrous*, when the fibres, whether straight or curved, are parallel to each other, as in common asbestus, and fibrous gypsum.

β. *Diverging fibrous*, when the fibres proceed from a common centre, in different directions; and this is either,

i. *Stellular diverging*, when the fibres diverge in all directions, like the radii of a circle, as in brown hematite.

ii. *Fasicular* or *scopiform*, when the fibres diverge only on one side, so that the middle fibres are often longer than the lateral ones, as in malachite, fibrous zeolite, and reniform red hematite.

γ. *Promiscuous fibrous*, when the fibres cross each other in all directions, as in compact plumose antimony.

D. *Radiated fracture*. The distinct concretions in this kind of fracture have two discernible dimensions, namely, in length and breadth, and of these the fisst is the most considerable. Hence the fracture surface exhibits long and narrow fracture parts, which sometimes rest on each other, or are placed side by side. The lustre alternates from splendent to shining, and the transparency from translucent to opaque. The minerals in which it occurs are sometimes crystallised either in needles, or in broad prisms. In the radiated fracture, we have to attend to the *breadth*, *direction*, *position*, and *cleavage* of the rays, and the *aspect* of the surface of the rays.

a. *The breadth of the rays*.

α. *Uncommonly broad radiated*, when the breadth of the rays is more than one-fourth of an inch, as is sometimes the case with radiated grey antimony, and kyanite.

β. *Broad radiated*, when the breadth of the rays is less than the fourth of an inch, but not less than a line, as in common actynolite and mica.

γ. *Narrow radiated*, when the breadth is even less than in the preceding, also in actynolite.

b. *Direction of the rays*.

α. *Straight radiated*, which is very frequent, as in actynolite.

β. *Curved radiated*, which is rare. The curvature is either in the direction of the *breadth*, as in common actynolite, or in the direction of the length, as in kyanite.

c. *Position of the rays*.

α. *Parallel radiated*, as in grey antimony, and in common hornblende.

β. *Diverging radiated*.

i. *Stellular*, as in radiated red cobalt-ochre, or cobalt-bloom.

ii. *Scopiform*, as in radiated grey antimony, and radiated zeolite.

γ. *Promiscuous*, as in hornblende-slate, and grey antimony.

d. *Cleavage*, or *passage of the rays*.

a. *Single cleavage*.

b. *Double Cleavage*, as in hornblende. In general, the cleavage, of which a particular account will be given when treating of the foliated fracture, is imperfect, and we seldom can distinguish more than one variety of it, which is the single.

e. *The aspect of the rays surface*. The rays are either

α. *Smooth*, as in radiated grey antimony and actynolite.

β. *Streaked*, as in radiated grey manganese-ore and hornblende.

E. *Foliated fracture*. This kind of fracture is composed of folia or planes in which the length and breadth are nearly equal; which are shining or splendent, and superimposed on each other in various directions. It occurs in minerals possessing every degree of transparency, which are generally crystallised, and usually afford regular fragments. It is a more frequent fracture than either the radiated or fibrous.

In the foliated fracture we have to attend to the *size of the folia*—the *degree of perfection of the foliated fracture*—the *direction of the folia*—the *position of the folia*—the *aspect of the surface of the folia*—and the *passage of the folia* or *cleavage*.

a. *The size of the folia*. The size of the folia is determined by that of the distinct concretions; so that a mineral which is composed of large granular concretions, must have a large foliated fracture, or, of small granular concretions, a small foliated fracture. When a mineral with a foliated fracture is not composed of distinct concretions, but is one uniform undivided mass, the folia pass uninterruptedly through the whole extent of the mass, and afford the largest variety of foliated fracture.

b. *The degree of perfection of the foliated fracture*. This depends on the facility with which the folia are separated from each other by splitting on the lustre, and the smoothness of the fracture surface. Thus it is

α. *Highly perfect* or *specular splendent*, when the folia are perfectly smooth, and specular splendent, as in galena or lead-glance, yellow blende, transparent calcareous-spar, and selenite.

β. *Perfect foliated*, in which the folia are pretty smooth and shining, and sometimes splendent, as in mica and felspar.

γ. *Imperfect foliated*, when the folia are slightly uneven, or even rough, and the lustre lower than in the perfect foliated, as in fluor spar, and beryl.

δ. *Concealed foliated*, when the folia are separated from each other with difficulty, and the foliated fracture appears only in a few places of the fracture surface, as in rock-crystal.

c. *The direction of the folia*.

α. *Straight foliated*, as in selenite and calcareous-spar.

β. *Curved foliated*, which is either

i. *Spherical curved foliated*, when the folia are so bent, that they resemble either whole spheres, or segments of spheres, as in brown-spar and mica.

ii. *Undulating curved foliated*, when the folia are so laid over each other, that a transverse section gives a serpentine line, but the longitudinal one a straight line, as in mica.

iii. *Floriform foliated*, when the folia are variously curved, and the curvatures are arranged in a scopiform manner, as in galena or lead-glance.

iv. *Indeterminate curved foliated*, when the folia are irregularly or indeterminately curved, as in iron-mica or micaceous iron-ore, and mica.

d. *The position of the folia.*

α. *Common foliated*, when the folia extend throughout the whole mass, and cover each other completely, as in calcareous-spar, and most other minerals with a foliated fracture.

β. *Scaly foliated*, when the folia cover each other only partially in their arrangement, somewhat resembling the scales on a fish. It is divided into *large*, *small*, and *fine* scaly foliated, and occurs in mica.

e. *The aspect of the surface of the folia.* The foliated fracture is either

α. *Smooth*, as in calcareous-spar, and felspar; or *Streaked*, which is either

i. *Simply streaked*, and in the direction of the length, as in common hornblende.

ii. *Variously streaked*, as in iron-mica.

iii. *Plumosely streaked*, as in mica.

f. *The passage of the folia* or *cleavage.*

The cleavage is the number of determinate directions in which a mineral exhibits a foliated fracture, and according to which it can be split.

It is distinguished

α. *According to the number of the cleavages.*

i. *Single*, when it splits only in one direction, as in mica.

ii. *Twofold* or *double*, when it splits in two directions, as in felspar, hornblende, and tremolite.

iii. *Threefold* or *triple*, when it splits in three directions, as in calcareous-spar, rock-salt, and galena or lead-glance.

iv. *Fourfold* or *quadruple*, when it splits in four directions, as in fluor-spar, specular iron, or iron-glance and beryl.

v. *Sixfold*, when it splits in six different directions, as in blende and rock-crystal.

β. *According to the angle under which the cleavages intersect each other*; and these exhibit the following varieties.

i. In the *twofold cleavage*, the two folia or cleavages intersect each other *rectangularly*, as in felspar and hyacinth; or *oblique angularly*, as in hornblende.

ii. In the *threefold cleavage*, the folia intersect each other *rectangularly*, as in galena or lead-glance; *oblique*, yet *equiangularly*, as in calcareous-spar and sparry ironstone; *oblique* but *unequiangularly*, as in heavy-spar; and partly *rectangularly*, partly *oblique-angularly*, as in selenite.

iii. In the *fourfold cleavage*, all the cleavages are *equiangular* and *oblique angular*, as in fluor-spar, iron-glance, and diamond; or three cleavages are *equiangular* and *oblique-angular*, in a common axis, and are intersected by a fourth, which is horizontal and rectangular, as in beryl.

iv. In the *sixfold cleavage*, all the cleavages meet under *equal oblique angles*, as in rock-crystal; or three of the cleavages are *equiangular* and *oblique-angular*, in a common axis, which are obliquely intersected by three others, which also intersect the axis in an oblique direction. Example, Blende.

These angles of the various cleavages may also be more particularly measured by means of the goniometer.

D. *Slaty fracture.* This fracture, like the foliated, consists of plane-like portions, in which the length and breadth are nearly alike, but in which the thickness begins to be discernible. The fracture-surface is generally rough, with but little lustre. It is nearly allied to the foliated fracture, but is less perfect, and never occurs in regularly crystallised minerals, but always in those which are found in large masses, or in beds. Minerals with this fracture are generally opaque. This fracture is further distinguished according to *thickness*, *direction*, *perfection*, and *cleavage.*

a. *Thickness.*

a. *Thick slaty*, as in alum-slate, flinty-slate, and clinkstone.

b. *Thin slaty*, as in most of the varieties of clay-slate.

b. *Direction.*

a. *Straight slaty*, as in common clay-slate.

b. *Curved slaty*, which is either,

aa. *Indeterminate curved slaty*, as in some varieties of bituminous marl-slate.

bb. *Undulating curved slaty*, as in glossy alum-slate.

c. *Perfection.*

a. *Perfect slaty*, as in clay-slate.

b. *Imperfect slaty*, as in common flinty-slate.

d. *Cleavage.*

a. *Single cleavage*, which is the usual variety in clay-slate.

b. *Double cleavage*, rare, as in clay-slate.

2. *Where several fractures occur at the same time, their relative situation must be observed.*

A. *One including the other.*

In some minerals there occurs a double fracture, in which the one fracture is larger than the other, and includes it; the one, the larger fracture, is named the *fracture in the great*; the other, the lesser, the *fracture in the small*; thus, whet-slate has in the great a slaty fracture, but in the small a splintery fracture.

B. *One traversing the other.*

In other minerals, where the fracture also is double, but in which the length and breadth are different, that fracture which is in the direction of the length is named the *longitudinal fracture*; the other, in the direction of the breadth, the *transverse* or *cross fracture.* Thus, in topaz, there is a conchoidal longitudinal fracture, and a foliated transverse or cross fracture. But in tessular crystals, where the length and breadth are nearly alike, we use, in place of the term *longitudinal fracture*, *principal fracture*, and apply it to that fracture which occurs the most frequent in breaking a mineral; the other fracture, *the cross fracture.* Thus in blende, the principal fracture is foliated, with a sixfold cleavage; but the cross fracture is conchoidal; and in drawing slate, the principal fracture is slaty, and the cross fracture is earthy.

VI. *The shape of the Fragments.*

Fragments are those shapes which are formed when a mineral is so forcibly struck or split, that masses having surrounding fracture surfaces are separated from it.

The fragments are either *regular* or *irregular*.

1. *Regular fragments*, are inclosed in a certain number of regular planes, that meet under determinate angles. They occur only in such minerals as have a foliated fracture, with several cleavages. Each cleavage in these regular fragments, forms two opposite parallel planes, and the shape of the fragment depends on the number of these planes, and the magnitude of the angles under which they meet. Minerals with a twofold cleavage do not afford perfect regular fragments. The following are the varieties of regular fragments:

A. *Cubic*, which occur in minerals possessing a rectangular threefold cleavage, as galena or lead-glance and rock-salt.

B. *Rhomboidal* or *oblique-angular*, which occur in minerals having a threefold cleavage, as calcareous-spar. When two cleavages intersect each other obliquely, and are intersected rectangularly by a third, the fragments are oblique-angular in one direction, and rectangular in another, as in felspar and selenite. In calcareous-spar, the fragments are specular on every side; but in felspar, owing to the imperfect third cleavage, only on four sides.

C. *Trapezoidal*. Occur in foliated coal.

D. *Tetrahedral* or *three-sided pyramidal* and *octahedral*, occur in minerals having a fourfold cleavage, in which the folia meet under equal angles, as in fluor spar. *Three* and *six sided prismatic fragments* occur in minerals having a fourfold cleavage, in which three of the cleavages are placed under equal angles around a common axis, and are rectangularly intersected by the fourth, as in beryl.

E. *Dodecahedral*. Fragments of this form occur in minerals having a sixfold cleavage. Sometimes three of the cleavages are disposed around an axis, and are obliquely intersected with other three, as in blende; in other instances, all the six cleavages intersect each other under equal hexagon angles, and terminate in an apex, forming *double six-sided pyramidal fragments*, as in rock-crystal.

2. *Irregular fragments*.

These have no regular form. They occur in minerals with a single cleavage, and in all the varieties of compact fracture. The following are the different varieties:

A. *Cuneiform*, in which the breadth and thickness are much less than the length, and gradually and regularly diminish in magnitude from one end to the other. It occurs in minerals possessing a scopiform radiated fracture, as Cornish tin-ore, red-hematite, and radiated zeolite.

B. *Splintery*, in which the breadth and thickness are less considerable than the length, but without diminution of magnitude from one extremity to the other. It occurs in minerals having parallel fibrous and radiated fractures, as in asbestus and bituminous wood.

C. *Tabular*, in which the breadth and length are more considerable than the thickness, and the middle is frequently thicker than the sides, which indeed are sometimes thin and sharp. It occurs in minerals with a single cleavage, as mica, also in slaty minerals, as clay-slate, and there is occasionally a tendency to it in minerals with a conchoidal fracture, as flint.

D. *Indeterminate angular*, in which the length, breadth, and thickness are in general nearly alike, but the edges differ much in regard to sharpness, which gives rise to the following distinctions.

a. *Very sharp-edged*, as in obsidian and rock-crystal.

b. *Sharp-edged*, as in common quartz, pitch-stone, and jasper.

c. *Rather sharp-edged*, as in basalt and limestone.

d. *Rather blunt-edged*, as in pumice and copper-pyrites.

e. *Blunt-edged*, as in gypsum and steatite.

f. *Very blunt-edged*, as in fuller's earth and loam.

III. THE ASPECT OF THE DISTINCT CONCRETIONS.

Distinct Concretions are those portions into which certain minerals are naturally divided, and which can be separated from one another without breaking through the solid or fresh part of the mineral. They are separated from one another by natural seams, and frequently lie in different directions. When they are very much grown together, the natural seams are scarcely visible; in such cases, however, they can be distinguished by their different positions and resplendent lustre. They have been confounded with crystals and fragments, from both of which, as is evident from the preceding definition, they are completely different.

Here we have to consider, 1. The *shape of the distinct concretions* 2. The *surface of the distinct concretions*; and, 3. The *lustre of the distinct concretions.*

VII. *The Shape of the Distinct Concretions.*

Distinct concretions, in regard to shape, are distinguished into *granular*, *lamellar*, and *columnar*.

1. *Granular distinct Concretions.*

When the concretions are tessular, or have their length, breadth and thickness, nearly alike, they are said to be granular. It is the most frequent form of the distinct concretion. They are distinguished according to *shape* and *magnitude*.

A. In regard to *shape*, they are

a. *Round granular*, which is either

α *Spherical*, as in pea-stone and roe-stone.

β. *Lenticular*, as in red granular clay-iron stone.

γ. *Date-shaped*, which is of a longish round shape, as in quartz rock near Cullen in Banffshire, and at Prieborn in Silesia.

b. *Angulo-granular*, which is either,

α *Common angulo-granular*, as in galena or lead-glance, and is very frequent.

β. *Longish angulo-granular*, as in red hematite and zeolite.

B. In regard to *magnitude*, into

a. *Large granular*, in which the size exceeds that of a hazel nut, as in galena or lead-glance, blende, and zeolite.

b. *Coarse granular*, in which the size varies from the size of a hazel-nut to that of a pea, as in galena or lead-glance, blende, mica, and pea-stone.

c. *Small granular*, in which the size varies from that of a pea to that of a millet-seed, as in galena or lead-glance, pea-stone, roe-stone, and black blende.

2. *Lamellar distinct Concretions.*

In the lamellar distinct concretions, the length and breadth are nearly alike, and more considerable than the thickness. They occur frequently, but not so often as the granular concretions.

They are distinguished in regard to *direction* and *thickness*.

A. In regard to *direction*, they are

a. *Straight lamellar*, which is either,

α. *Quite straight*, as in straight lamellar heavy-spar, or

β. *Fortification-wise bent*, as in amethyst.

b. *Curved lamellar*, which is either,

α. *Indeterminate curved lamellar*, when it is not curved in any particular direction, as in specular iron-ore or iron-glance.

β. *Reniform curved lamellar*, as in red and brown hematite, and native arsenic.

γ. *Concentrical curved lamellar*, when they are disposed around a central point. It is divided into *spherical*, as in calcedony and basalt, and *conical*, as in calc-sinter and brown hematite.

B. In regard to *thickness*, into

a. *Very thick lamellar*, when the concretions are upwards of half an inch thick, as in amethyst, and galena or lead-glance.

b. *Thick lamellar*, when the thickness varies from half an inch to a quarter of an inch.

c. *Thin lamellar*, when the thickness varies from a quarter of an inch to a line, as in straight lamellar heavy-spar and calcedony.

d. *Very thin lamellar*, from that of a line, or the one-twelfth of a line, to the smallest thickness visible to the naked eye, as in straight lamellar heavy-spar, native arsenic, and specular iron-ore or iron-glance.

3. *Columnar or Prismatic distinct Concretions.*

In the columnar concretions, the breadth and thickness are inconsiderable in comparison of the length.

They are distinguished in regard to *direction*, *thickness*, *shape*, and *position*.

A. In regard to *direction*, they are,

a. *Straight columnar*, as in schorl and calcareous-spar.

b. *Curved columnar*, as in columnar clay iron-stone.

B. In regard to *thickness*, they are

a. *Very thick columnar*, when the thickness exceeds half an inch, as in amethyst and prase.

b. *Thick columnar*, from half an inch to a quarter of an inch, as in quartz and calcareous-spar.

c. *Thin columnar*, from half an inch to the twelfth of an inch, as in columnar clay iron-stone and schorl.

d. *Very thin columnar*, when it does not exceed the twelfth of a line, as in schorl. When the concretions become very minute, a transition is formed into the fibrous fracture.

C. In regard to *shape*, they are,

a. *Perfect columnar*, when the length is considerable, and the thickness uniform from one end to the other, as in calcareous-spar and schorl.

b. *Imperfect columnar*, when the concretions are in general short, and sometimes thick in the middle, sometimes at the extremities, as in amethyst and specular iron-ore or iron-glance. It passes into granular.

c. *Cuneiform columnar*, when the concretions become gradually narrower towards one extremity, as in calcareous-spar and quartz.

d. *Ray-shaped columnar*, when the columnar concretions are compressed, as in specular iron-ore or iron-glance. It passes into radiated.

D. According to the *position*, they are

a. *Parallel*, as in amethyst.

b. *Diverging*, as in schorl.

c. *Promiscuous*, as in calcareous-spar and arsenical-pyrites.

It may be remarked, that when the concretions occur very much on the great scale, as is the case in rocks of the trap formation, a slight alteration of terms is used. Thus, in place of *granular*, we say *massive*, *tabular* for *lamellar*, and always use *columnar*, never *prismatic*.

In several minerals, two varieties of distinct concretions, or different sizes of the same variety, occur together, either the one including the other, or the one traversing the other. Thus some varieties of schorl are composed of large granular concretions, and these, again, are formed of prismatic concretions; some varieties of straight lamellar heavy-spar, are composed of large granular concretions, and these, again, of thin and straight lamellar concretions; and peastone affords another example of the same kind of structure, it being composed of round granular concretions, and each of these of concentric curved lamellar concretions.

In other minerals we observe different kinds of distinct concretions intersecting each other, as in amethyst, where curved lamellar concretions intersect prismatic concretions, and in red and brown hematite, where granular concretions are intersected by lamellar concretions.

VIII. *The Surface of the Distinct Concretions.*

Distinct concretions exhibit the following varieties of surface.

Smooth, as in hematite and heavy-spar; *rough*, as in clay ironstone; *streaked*, which is either *longitudinally* streaked, as in schorl, *obliquely* streaked, as in calcareous-spar, or *transversely* streaked, as in amethyst; *uneven*, as in brown blende.

IX. *The Lustre of the Distinct Concretions.*

It is determined in the same manner as the external lustre.

V. THE GENERAL ASPECT.

Under this head we include those characters for the sight which are observed in minerals in general. These are, the *Transparency*, the *Streak*, and the *Soiling*.

X. *The Transparency.*

This character presents the five following degrees:

1. When a mineral, either in thick or thin pieces, allows the rays of light to pass through it so completely that we can clearly distinguish objects placed behind it, it is said to be transparent. It is either *simply transparent*, that is, when the body seen through it appears single, as in mica and selenite; or *duplicating*,

when the body seen through it appears double, as in calcareous-spar.

The distance of the two images is in proportion to the thickness of the specimens, and is very inconsiderable in thin pieces. The duplicating property, or double refracting power of calcareous spar, is observed by looking through two parallel planes; but in some other minerals it is observed by looking through two planes obliquely inclined on each other.

2. *Semi-transparent;* when objects can be discerned only through a thin piece, and then always appear as if seen through a cloud. It is the least frequent variety of this character, and occurs most frequently in siliceous minerals. Examples, calcedony, common and precious opal, and carnelian.
3. *Translucent.* When the rays of light penetrate into the mineral and illuminate it, but objects cannot be observed either through thick or thin pieces, it is said to be translucent. Examples, pitchstone, quartz, granular limestone, and massive fluor spar.
4. *Translucent on the edges.* When light shines through the thinnest edges and corners, or when the edges are illuminated in the same degree as the whole mineral in the immediately preceding variety of transparency, it is said to be translucent on the edges. Examples, hornstone, heliotrope, and compact limestone.
5. *Opaque.* When even on the thinnest edges of a mineral no light shines through, it is said to be opaque, as in chalk and coal.

XI. *The Opalescence.*

Some minerals, when held in particular directions, reflect from single spots in their interior a coloured shining lustre, and this is what is understood by opalescence.

It is distinguished into

A. *Common* or *simple opalescence*, when the lustre appears massive, in undivided rays, as in cat's-eye, and chrysoberyl.

B. *Stellular opalescence*, when the lustre appears in six rays, or in the form of a star, as in the variety of sapphire, named from that circumstance *star sapphire.* This phenomenon occurs principally in translucent minerals.

XII. *The Streak.*

By the streak, we understand the appearance which minerals exhibit when scratched or rubbed with a hard body, as a knife or steel. In some instances the colour of the mineral is changed; in others the lustre, and frequently neither colour nor lustre are altered.

The *streak*,

a. *In regard to colour*, is either
  α. *Similar* to that of the mineral, as in chalk and magnetic ironstone; or
  β. *Dissimilar*, as in specular iron ore or iron-glance, which has a steel-grey colour, but affords a cherry-red streak; wolfram, which has a greyish black colour, but a brownish red streak; and red orpiment, which has an aurora red colour, but affords an orange-yellow streak.

b. *In regard to lustre*, it remains
  α. *Unchanged*, as in chalk.
  β. *Is increased in intensity*, or *a shining or glistening lustre appears in minerals that otherwise have none.* Thus steatite, which is sometimes glimmering, becomes shining in the streak; and potter's clay, fuller's earth, and black and brown cobalt ochres, which have no lustre, become glistening or shining in the streak.
  c. *Is diminished in intensity*, or *altogether destroyed.* Thus, grey antimony-ore loses its lustre in the streak.

XIII. *The Soiling or Colouring.*

When a mineral taken between the fingers, or drawn across another body, leaves some particles, or a trace, it is said to *soil* or *colour.*

It is a character which occurs but in few minerals, and only in those which are soft and very soft. Minerals are said to

1. *Soil*, either
  A. *Strongly*, as chalk, drawing-slate, and reddle.
  B. *Slightly*, as graphite; or
2. *Do not soil*, as molybdena.
3. *Write*, as chalk, graphite, reddle, molybdena, and black chalk or drawing-slate.

Having now explained the External Characters which are observable by the sight, we proceed to describe those which are made known to us by the senses of Touch and Hearing.

V. CHARACTERS FOR THE TOUCH.

Here we have to observe, the Hardness, the Tenacity, the Frangibility, the Flexibility, the Adhesion to the Tongue, the Unctuosity, the Coldness, and the Weight.

XIV. *The Hardness.*

The degrees are

1. *Hard.* When a mineral either does not yield to the knife, or is very slightly affected by it, but affords sparks with steel, it is said to be hard. It is further distinguished according as it is more or less affected by the file.
  A. *Resisting the file*, or *hard in the highest degree*, when it does not yield to the file, but rather acts on it, as diamond, sapphire, and emery.
  B. *Yielding slightly to the file, and very slightly to the knife*, or *hard in a high degree*, as in garnet, flint, quartz and calcedony.
  C. *Yielding readily to the file, but with difficulty to the knife, or hard*, as porcelain-jasper, iron-pyrites, and felspar.
2. *Semihard.* When a mineral gives no sparks with steel, and yields more readily to the knife than the preceding, it is said to be semihard, as fluor-spar, and grey copper.
3. *Soft.* When a mineral is easily cut by the knife, but does not yield to the nail of the finger, it is said to be soft, as calcareous-spar, heavy-spar, serpentine, and galena or lead-glance.
4. *Very soft.* A mineral is said to be very soft, when it yields easily to the knife, and also to the nail of the finger, as gypsum, steatite, and chalk.

In our descriptions of minerals, it is useful to mention their relative hardness, which is ascertained by trying which will scratch the other, by drawing the sharp edge or angle of one on the flat surface of the other. It is, however, of consequence to know, that in crystallized minerals, the solid angles and edges of the primitive forms are very sensibly harder than the angles and edges of the derivative forms, or than the angles and edges produced by fracture, either of crystals or of massive varieties of the same species. This fact has been long known to diamond cutters, who always carefully distinguish between the *hard* and *soft* points of this gem, that is, between the solid angles belonging to the primitive octohedron, and those belonging to any of the modifications; the latter being easily worn down by cutting and rubbing them with the former*. Hauy, in determining the relative hardness, uses plates of calcareous-spar, glass, and quartz; but as it would be advantageous to have a more complete series of minerals for ascertaining these relative degrees of hardness, I insert the following Table of Minerals, arranged according to their hardness, the first being the hardest, the last the softest. We would recommend to mineralogists to provide themselves with polished pieces of these, and arrange them in a frame for use.

The following are the different degrees of hardness.

1. Expresses the hardness of	Talc.
2.	Gypsum.
3.	Calcareous spar.
4.	Fluor-spar.
5.	Apatite.
6.	Felspar.
7.	Quartz.
8.	Topaz.
9.	Corundum.
10.	Diamond.

Thus, if the hardness of a mineral is marked 7, it shows that it is equal to that of quartz. If the hardness is marked 7 5, it intimates that it is intermediate between that of quartz and the next number, 8, or topaz. By using still smaller numbers, more minute degrees of hardness might be expressed.

Observations. In examining the hardness of minerals, we must be careful to attend to the following circumstances:

1. Not to confound the real hardness of the mineral with accidental hardness; which latter is caused by the mixture of hard parts in soft minerals, and soft parts in hard minerals.

2. When minerals are composed of distinct concretions, which are not very closely joined together, we must not give the hardness of the aggregate for that of the mineral, because the hardness in such cases must be taken from that of the individual concretions.

3. And we must be careful that the mineral whose hardness we wish to ascertain, is not in a state of decomposition.

XIV. *The Tenacity.*

By tenacity is understood the relative mobility or the different degrees of cohesion of the particles of minerals. There is a series from the coherent and completely immoveable, to the coherent and moderately moveable, which latter is expressed by malleability, and is the greatest degree of the mobility of the particles observed among solid minerals. This series continues through different kinds of fluid minerals, and the greatest degree of the mobility of the particles is found in rock-oil. The degrees of tenacity are,

1. *Brittle.* A mineral is said to be brittle, when, on cutting it with a knife, it emits a grating noise, and the particles fly away in the form of dust, and leave a rough surface, which has in general less lustre than the fracture. In this degree of tenacity, the particles are completely immoveable. All hard, and the greater number of semihard minerals are brittle. Examples, quartz, heavy-spar, and grey copper.

2. *Sectile* or *mild.* On cutting minerals possessing this degree of tenacity, the particles lose their connection in a considerable degree, but this takes place without noise. The particles are coarser than in the brittle variety, and do not fly off, but remain on the knife. The lustre is increased on the streak. This degree of tenacity occurs in most of the soft and very soft minerals; and the only semihard mineral with this character is native arsenic. Examples, galena or lead-glance, copper-glance, graphite, and molybdena.

3. *Ductile.* Minerals possessing this degree of tenacity can be cut into slices with a knife, and extended under the hammer. The particles are more or less moveable among themselves, without losing their connection. Examples, native gold, native silver, and native iron.

XV. *The Frangibility.*

By frangibility is understood the resistance which minerals oppose when we attempt to break them into pieces or fragments. It must not be confounded with hardness Quartz is hard, and hornblende comparatively soft, yet the latter is much more difficultly frangible than the former. The degrees of frangibility are the following: 1. *Very difficultly frangible*, as in native malleable metals, in silver-glance, or vitreous silver, and fine granular hornblende. 2. *Difficultly frangible*, as hornstone and quartz. 3. *Not particularly difficultly frangible*, or *rather easily frangible*, as flint, calcedony, and copper-pyrites. 4. *Easily frangible*, as opal, calcareous-spar, and fluor-spar. 5. *Very easily frangible*, as straight lamellar heavy spar, galena, or lead-glance, and slate coal.†

XVI. *The Flexibility.*

This term expresses the property possessed by some minerals of bending without breaking. Flexible minerals are either *elastical flexible*, that is, if when bent they spring back again into their former direction, as mica; or *common flexible*, when they can be bent in different directions without breaking, and remain in the direction in which they have been bent, as molybdena, gypsum, talc, asbestus, and all malleable minerals.

XVII. *The Adhesion to the Tongue.*

This character occurs only in such minerals as possess the property of absorbing moisture, which causes them to adhere to the tongue. It occurs principally in soft and very soft minerals; it is not known in hard

* Vid. Bruckmann's Abhandlung von Edelsteinen, 4ter Aufl. s. 28. & 29. Mohs uber Hauy's Meionite, in Von Moll's Efermeriden der Berg und Huttenkunde 2ten Bandes, 1ste Lief, s. 3. Aiken's *Manual*, p. 5.

† Some earthy minerals, such as beryl, flint, and opal, when first extracted from their native repositories, are more difficultly frangible than after they have been exposed for some time to the influence of the atmosphere, owing to their containing in these situations a considerable portion of water, which, being a nearly incompressible fluid, renders the mineral more difficultly frangible than it is after exposure to the atmosphere, when the water has escaped, and the pores it occupied become filled with air, which is a highly compressible substance.—*Vide* Aikin, p. 9.

minerals, and there is but one instance of its occurrence in semihard minerals, that is, in the variety of semiopal called *oculus mundi.* The degrees of adhesion are, *strongly adhesive*, as meerschaum, and oculus mundi; *pretty strongly* adhesive, as bole, and potter's clay; *feebly adhesive*, as porcelain-earth, chalk, and tripoli; and *not at all adhesive*, as quartz and steatite.

XVIII. *The Unctuosity.*

Some minerals feel *greasy*, others *meagre;* and in order to distinguish the different degrees of greasiness, the following distinctions are employed.

1. *Very greasy*, as talc and graphite.
2. *Greasy*, as steatite and fuller's earth.
3. *Rather greasy*, as asbestus and polished serpentine.
4. *Meagre*, as cobalt.

The greasy and very greasy minerals are generally very soft and sectile, and become shining in the streak. Mica feels smooth, but not greasy; porcelain earth feels soft and fine, but not greasy.

XIX. *The Coldness.*

When different kinds of minerals, all having equally smooth surfaces, are exposed for some time to the same temperature, we find by feeling them that they possess different degrees of cold. To use this character with precision much practice is required; but those who have accustomed themselves to it are able, by the mere feel, to distinguish serpentine, gypsum, porphyry, alabaster, agate, &c. from one another, and can also distinguish artificial from true gems. It is, however, principally used in determining polished specimens. The different degrees mentioned are,

1. *Very cold.* Examples, the precious stones, mercury and agate.
2. *Cold.* Examples, Polished marble or limestone.
3. *Pretty cold.* Examples, Serpentine, and gypsum or alabaster.
4. *Rather cold.* Examples, Coal and amber.

XX. *The Weight.*

The degrees of the gravity of minerals, according to Werner, are the following:

1. *Swimming*, or *supernatant*, which comprehends all minerals that swim on water, and in which the specific gravity is under 1000, water = 1000. Examples, Mineral oil, mountain cork, and mineral agaric.
2. *Light*, in which the specific gravity varies from 1000 to 2000. Examples, Amber, sulphur, and black coal.
3. *Not particularly heavy*, or *rather heavy*, in which the specific gravity varies from 2000 to 4000. Examples, Quartz, flint, and calcedony.
4. *Heavy*, from 4000 to 6000. Examples, Heavy-spar, copper-pyrites, and iron-pyrites.
5. *Uncommonly heavy*, all minerals having a specific gravity above 6000. Examples, Native metals, as gold, silver, &c.; ores, as galena or lead-glance, tinstone, &c.

The first and second degrees, which comprehend the swimming and light minerals, contain all the inflammable minerals; the third, with a few exceptions, all the earthy minerals; the fourth, the greater number of metalliferous compounds; and the fifth, the native metals and a few ores, &c.

The preceding determinations answer very well for the general descriptions of species; but it renders them more complete, when we ascertain the specific gravity by means of the hydrostatic balance. See the article HYDRODYNAMICS, for the mode of conducting this experiment.

VI. CHARACTERS FOR THE HEARING.

XXI. *The Sound.*

The different kinds of sound that occur in the mineral kingdom are the following: 1. *A ringing sound*, which is a clear sound, as that of native arsenic, selenite, and rock-crystal. Specimens to possess this property in full perfection, should have one or two dimensions, as length and breadth, greater than the thickness: 2. *A grating sound*, which is a very weak rough sound, resembling that emitted by dry wood, or fresh burnt clay when rubbed, and is produced when the finger is drawn across certain minerals, as mountain cork and mealy zeolite: 3. *A creaking sound*, which is a harsh sharp sound, as that of natural amalgam, when pressed by the finger.

VII. CHARACTERS FOR THE SMELL.

Of this we can give no definition, and shall therefore illustrate it by the minerals in which it occurs.

It is observed, either when

1. *Spontaneously emitted*, in which case it is
   - *a. Bituminous*, as mineral oil and mineral pitch.
   - *b. Faintly sulphureous*, as natural sulphur.
   - *c. Faintly bitter*, as radiated grey antimony.
2. *After breathing on it*, in which a *clayey-like smell*, as in hornblende and chlorite, is produced.
3. *Excited by friction.*
   - *a. Urinous*, in stinkstone.
   - *b. Sulphureous*, in iron pyrites.
   - *c. Garlick-like*, or *arsenical*, in native arsenic and arsenic pyrites.
   - *d. Empyreumatic*, in quartz and rock crystal.

VIII. CHARACTERS FOR THE TASTE.

This character occurs principally in the saline class, for which it is highly characteristic.

The varieties of it are,

1. *Sweetish taste*, common salt.
2. *Sweetish astringent*, natural alum and rock butter.
3. *Styptic*, blue and green vitriol.
4. *Saltly bitter*, natural Epsom salt.
5. *Saltly cooling*, nitre.
6. *Alkaline*, natural soda.
7. *Urinous*, natural sal-ammoniac.

II. PARTICULAR GENERIC EXTERNAL CHARACTERS OF FRIABLE MINERALS.

The external characters of friable minerals form a particular Section in the System, because they exhibit varieties and kinds that do not occur in solid minerals, and many of the characters of solid minerals, such as fracture, distinct concretions, streak, hardness, and frangibility, and others, are wanting.

I. *The External Shape.*

In friable minerals there are but few external shapes. The five following kinds are all that have been hitherto described by naturalists.

1. *Massive*, as in porcelain earth, and scaly red and brown iron ores.

2. *Disseminated*, as in earthy azure copper, and blue iron earth.

3. *Thinly coating* or *incrusting*. It is analogous to the form in membranes. Examples, Copper-black, or black oxide of copper.

4. *Spumous*. When a friable mineral appears like froth resting on a solid mineral, as is sometimes the case with scaly brown iron ore.

5. *Dendritic*, also in scaly brown iron ore.

II. *The Lustre.*

It is determined in the same manner as in solid minerals; we have here, however, the following distinctions.

1. In regard to *Intensity*.
   A. *Glimmering*, which is either strong or feeble, as in scaly brown iron ore, and porcelain-earth.
   B. *Dull*, as in black cobalt ochre.
2. In regard to the *sort* of lustre.
   A. *Common glimmering*, as in scaly and brown iron ores.
   B. *Metallic glimmering*, as in scaly red and brown iron ores, and *Pearly glimmering*, as in earthy talc.

III. *The Aspect of the Particles.*

The particles of friable minerals appear in some instances like dust, so that we can with difficulty distinguish by the naked eye any dimensions; these are called *dusty particles*, and occur in cobalt crust, blue iron earth, and porcelain earth; in others, two dimensions can be observed, when they appear foliated, and these are called *scaly particles*, and occur in scaly brown and red iron ores, earthy talc, and chlorite earth.

IV. *The Colouring or Soiling.*

Friable minerals colour either strongly, as in scaly red and brown iron ores, and porcelain earth; or slightly, as in black cobalt ochre.

V. *The Adhesion to the Tongue.*

This character occurs only in those friable minerals which are cohering. It varies in intensity, being either feeble or strong.

VI. *The Friability.*

Friable minerals are either loose, that is, when the particles have no perceptible coherence, as in blue iron earth; or cohering, in which the particles are slightly connected together; they are either feebly cohering, as in porcelain earth, or strongly cohering, as in potter's clay.

III. PARTICULAR GENERIC EXTERNAL CHARACTERS OF FLUID MINERALS.

Fluid minerals possess fewer characters than friable minerals. The following four are all that occur.

1. *The Lustre* is either metallic, as in mercury; or resinous, as in rock oil. The lustre is always splendent.

2. *The Transparency.* The following are all the degrees necessary for the purposes of discrimination. 1. *Transparent*, as in naphtha. 2. *Troubled* or *turbid*, as in mineral oil; and, 3. *Opaque*, as in mercury.

3. *The Fluidity.* Here we have only two degrees to observe. 1. *Fluid*, as in mercury and naphtha. 2. *Viscid*, as is sometimes the case with mineral oil.

4. *The wetting*, by which we understand the wetting of the fingers when they touch the mineral. It is analogous to the soiling in solid and friable minerals. Mineral oil wets the finger, but mercury does not.

ON DESCRIBING MINERALS.

Most of the species exhibit many varieties of character, which are generally distributed throughout a number of individual specimens; hence it follows, that, in order to obtain a distinct conception of a species, we must examine not one, but many different specimens of it. The descriptions of the species may be executed in the following manner.

The following description may serve as an example of the mode of arranging the external characters.

Precious Garnet.

External Characters.—All the colours of this mineral are *deep-red*, which always inclines to blue; the principal colour is *columbine-red*, which passes into *cherry-red*, and *blood-red*, and it appears even to run into *brownish-red*, and *hyacinth-red*.

It rarely occurs massive, sometimes *disseminated*, in *angular pieces*, and in *lamellar concretions;* but most frequently in *roundish grains;* and *crystallized* in the following figures:

1. The *rhomboidal dodecahedron*, which is the fundamental figure.
2. The rhomboidal dodecahedron, *more or less deeply truncated on all the edges.* When the truncating planes become so large as to obliterate the original planes, there is formed the
3. *Leucite crystallization.*
4. *Rectangular four-sided prism*, acuminated on both extremities with four planes, which are set on the lateral edges.

The fundamental crystallization alternates from very large to very small; the others are middle-sized, small, and very small.

The crystals are *all around crystallized* and *imbedded.*

The *surface* of the grains is usually *rough, uneven*, or *granulated;* that of the crystals is almost always *smooth.*

Internally it alternates from *splendent* nearly to glistening, and the lustre is intermediate between *vitreous* and *resinous.*

The fracture is *more or less perfect conchoidal;* and sometimes *six fold cleavage.*

The fragments are indeterminate angular, and rather sharp-edged.

It alternates from *transparent* to *translucent.*

It is so hard as to scratch quartz.

It is rather difficultly frangible.

It is heavy.

Specific gravity, 4.230, Werner.

Werner recommends the more essential characters of the mineral to be printed in a different letter from that of the others, in order that they may more readily strike the eye,—a practice which is followed in the preceding description.

CHEMICAL CHARACTERS OF MINERALS.

The chemical characters of minerals are those we obtain by their complete analysis, and the changes induced on them by the action of the atmosphere, water, acids, and heat, by means of the blowpipe. In this article, we shall not enter on the various modes followed by chemists in the complete analysis of minerals, but confine ourselves to a short account of the chemical characters obtained by the other means just enumerated.

1. *Action of the Atmosphere.*

Many minerals, on exposure to the atmosphere, experience considerable changes in colour, lustre, hardness, or decay, fall in pieces, deliquesce, change into vitriol, &c. owing partly to the abstraction of the water, which enters as a constituent part into many species, partly to the absorption of water from the atmosphere, or to the oxidation of some of the constituent parts of the mineral.

2. *Action of Water.*

Water either forms a chemical combination with minerals, and completely dissolves them, as is the case with the mineral salts; or it acts by simply destroying their state of aggregation, when the mineral falls into small pieces with an audible noise, as is observed in bole: or it falls without noise into small pieces, which are soon diffused through the fluid, without either dissolving in it, or becoming plastic, as in fuller's earth; and some minerals, as unctuous clays, it renders plastic. Other minerals absorb water in greater or less quantity, by which their transparency, and also their colour, are changed.

3. *Action of Acids.*

Acids act powerfully on many different minerals, and are the principal agents employed in their complete analysis. When we wish, by means of acids, to obtain some obvious characters, the dilute muriatic acid is that which is generally employed. The native carbonates effervesce, and are soluble in it. In some, as in agaric mineral, calcareous-spar, and witherite, the effervescence is brisk, and the solution rapid; in others, as in dolomite, even when pulverised, the effervescence is feeble, and the solution slow. Some of the earthy minerals which contain silica, water and alkali, in a particular state of combination, as zeolite, if pulverised, and covered with an acid, are, in the space of a few hours, converted into a perfect jelly.

4. *Action of the Blowpipe.*

Common blowpipe.—The blowpipe is a tube of silver, copper, brass, or of glass, for delivering a continued stream of air. The stream being directed across a flame, turns it more or less from a vertical position, concentrating it at the same time, and occasioning a more powerful combustion. The air employed is generally either that of the atmosphere, or air which has been breathed: sometimes oxygen gas is made use of, and sometimes an inflammable gas, as the vapour of boiling alcohol. The continued stream of air is furnished by some apparatus, such as a pair of double bellows, a gazometer, a large bladder, or, what is most convenient of all, by blowing with the mouth.

Few persons, Mr. Aikin remarks, are able at first to produce a continued stream of air through the blowpipe, and the attempt often occasions a good deal of fatigue. The first thing to be done is, to acquire the habit of breathing easily, and without fatigue, through the nostrils alone; then to do the same when the mouth is filled and the cheeks inflated with air, the tongue being at the same time slightly raised to the roof of the mouth, in order to obstruct the communication between the mouth and the throat. When this has been acquired, the blowpipe may be put into the mouth, and the confined air expelled through the pipe by means of the muscles of the cheeks; as soon as the air is nearly exhausted, the expiration from the lungs, instead of being made through the nostrils, is to be forced into the cavity of the mouth; the communication is then instantly to be shut again by the tongue, and the remainder of the expiration is to be expired through the nostrils. The second, and all subsequent supplies of air to the blowpipe, are to be introduced in the same manner as the first. Thus, with a little practice, the power may be obtained of keeping up a continued blast for a quarter of an hour, or longer, without inconvenience. Much depends on the size of the external aperture of the blowpipe. If so large that the mouth requires very frequent replenishing, the flame will be wavering, and the operator will soon be out of breath; if, on the other hand, the aperture be too small, the muscles of the cheeks must be strongly contracted, in order to produce sufficient current, and pain and great fatigue of the part will soon be the consequence. An aperture, about the size of the smallest pinhole, will generally be found the most convenient, though, for particular purposes, one somewhat larger, or a little smaller, may be required.

Brooke's Blowpipe.

Mr. Brooke some time ago contrived a very simple and convenient blowpipe, of which the following description is given by Mr. Neuman.

"The instrument I have made consists of a strong plate-copper box, perfectly air-tight, three inches in width and height, and four in length, a condensing syringe to force air into the box, and a stop-cock and jet at one end of it to regulate the stream thrown out. The piston-rod of the condenser works through collars of leather in the cap, which has an aperture in the side, and a screw connected with a stop-cock, which may again communicate with a jar, bladder, or gazometer, containing oxygen, hydrogen, or other gases. This communication being made, and the condenser being worked, any air that is required may be thrown into the box and propelled through the jet on the flame.

"The use of the instrument is very simple. By a few strokes of the piston, the air is thrown into the chamber, and forms a compressed atmosphere within. When the cock is opened, the air expanding, issues out with great force, in a small but rapid stream, which, when directed on the flame of a lamp, acts as the jet from a common blowpipe, but with more precision and regularity. The force of the stream of air is easily adjusted by opening more or less the small stop-cock; and I have found, that, with a moderate charge, it will remain uniform for twenty minutes; opening the stop-cock, or the use of the syringe, will immediately raise it to its first strength.

These blowpipes are very portable, not liable to injury, and answer, I believe, the expectations of all who have tried them, and I have made many of them for different persons. The whole instrument, with a lamp adapted to it, packs up in a small box not more than six inches in length, and four inches in width and height, and there is space enough left for other small articles. I have fitted up boxes rather larger in size, with a selection of tests and other useful articles, in addition to the blowpipe, and in this state they form complete mineralogical travelling cabinets."

Fuel for the Blowpipe.

The fuel for the lamp is oil, tallow, or wax; and of these the wax is the best, the oil the worst. The wick should neither be snuffed too high nor too low, and should be a little bent at its summit *from* the blast of the pipe. The flame, while acted on by the blowpipe, will consist of two parts, an outer and inner: the latter will be of a pale blue colour, converging to a point at the distance of about an inch from the nozzle; the former will be of a yellowish colour, and will converge less perfectly. The most intense heat is just at the point of the blue flame. The white flame consists of matter in a state of full combustion, and oxygenates substances immersed in it: the blue flame consists of matter in a state of imperfect combustion, and therefore partly deoxygenates metallic oxides which are placed in contact with it.

Supports for minerals exposed to the Blowpipe.

Various substances are employed for supporting the mineral, when undergoing the action of the blowpipe. These are of two kinds, combustible and incombustible. The combustible support, used chiefly for ores, is charcoal. The closest grained and soundest pieces of charcoal, of elder or lime-tree, are to be selected; or a support may be made of well pulverised and heated charcoal and gum tragacanth. The gum should be dissolved in water, and powder of charcoal added to it, until it becomes very viscid, when it is to be formed into parallelopipeds, and slowly dried. The incombustible supports are metal, glass, and earth; in the use of all which, one general caution may be given, to make them as little bulky as possible. The best metallic support is platina, because it is infusible, and transmits heat to a less distance, and more slowly, than other metals. A pair of slender forceps of brass, pointed with platina, is the best support for non-metallic minerals, which are not very fusible; for the fusible earthy minerals, and for the infusible ones when fluxes are used, leaf-platina will be found the most convenient. It may be folded like paper into any form, and the result of the experiment may be obtained, simply by unfolding the leaf in which it was wrapped up. Glass supports, are slender glass tubes, on the extremity of which the mineral to be examined is cemented by heating. Earthen supports are, either of small pieces of kyanite, or, when a kind of cuppellation is to be performed, they are made of bone-ash, in order to absorb the litharge, and other impurities.

The size of the specimens to be used in our experiments, depends in some measure on the magnitude of the flame to which they are exposed. In a blowpipe having an aperture not larger than a fine pin, the piece ought not to be so large as a pea. A good deal also depends on the fusibility of the mineral; for, if it is very fusible, a much larger piece may be used than when it is difficultly fusible: in the one case, it may be the size of a pea: in the other, it should not exceed that of a pin's head. The heat first applied to investigate the properties of mineral substances should be very low, not exceeding that which exists a little the outside even of the yellow flame. At this temperature the phosphorescence is best extricated, and decrepitation for the most part takes place, the fusible inflammables begin to melt, and the metallic and most other mineral salts lose their water of crystallization. The yellow flame will raise a mineral to a tolerably full red heat; and it is the temperature best fitted for roasting all the metallic ores. In the still higher degree of heat produced at the point of the interior blue flame, although some minerals still continue refractory, and undergo but little change of any kind, yet the greater part are very sensibly altered. Some, as pearlstone, enlarge very considerably in bulk at the first impression of the heat, but are with difficulty afterwards brought to a state of fusion: others are melted only on the edges and angles; and in some, a complete fusion takes place.

Fluxes for Minerals exposed to the Blowpipe.

In examining earthy minerals with the blowpipe, no fluxes are required; whereas to most of the metallic ores fluxes will be found at almost all times a very useful and often a necessary addition. The ores of the difficultly reducible metals, such as manganese, cobalt, chrome, and titanium, are characterised by the colours which the oxides give to glass. In all these cases, therefore, glassy fluxes must be largely made use of, both to dissolve the earthy matter with which the oxides are generally combined, and to furnish a body, with little or no colour of its own, which may receive, and sufficiently dilute, the inherent colour of the oxide. When the object is not only to dissolve the oxide, but at the same time to retain it at a high state of oxidation, the flux employed should be either nitre, or a mixture of this with glass of borax, or, still better, nitrous borax, formed by dissolving common borax in hot water, neutralizing its excess of alkali by nitrous acid, then evaporating the whole to dryness, and, lastly, hastily melting it in a platina crucible. For an active, and at the same time non-alkaline flux, boracic acid may be used, or neutral borate of soda; and where a slight excess of alkali is required, or at least does no harm, common borax by itself, or mixed with a little cream of tartar, when a strong reducing flux is required, may be had recourse to. For coloured glasses, the proper support is leaf-platina, but for reductions, charcoal. In the latter case, the ore, previously roasted, if it contain either sulphur or arsenic, is to be pulverised, and accurately mixed with the flux; a drop of water being then added to make it cohere, it is to be formed into a ball, and deposited in a shallow hole in the charcoal, being also covered with a piece of charcoal, if a high degree of heat is required. In the easily reducible metals, a bit of the ore being placed in the charcoal, and covered with glass of borax, will, in the space of a few seconds, be melted by the blowpipe, and converted into a metallic globule, imbedded in a vitreous scoria. In all cases where a metallic globule is obtained, it should be separated from the adhering scoria, and examined as to its malleability, and other external characters; being then placed a second time on the charcoal, but without flux, it is to be brought to the state of a gentle ebullition, during which, the surface being oxygenated, will exhale a heavy vapour, that condenses on the blowpipe, or falls down on the charcoal in the form of a powder, or of specular crystals, from the colour and other characters of which the nature of the metal may probably be ascertained. If any suspicion is entertained of a portion of silver or of gold being mixed with the oxydable metal, the button must be placed on an earthen support, and there brought to a full melting heat: by degrees, the oxydable metal will become scorified, and will entirely sink into the support, leaving on the surface a bright bead of *fine metal*, if any such was contained in the alloy; but the proportion of this last being generally very small, and the entire mass of the alloy often not exceeding a large shot, it is not unfrequently necessary to have recourse to the magnifying glass, to be fully convinced of the presence or absence of the fine metal.*

PHYSICAL CHARACTERS OF MINERALS.

Physical characters are those derived from physical phenomena originating from the mutual action of minerals and other bodies. They are highly curious in a general view, but are seldom useful in the discrimination of minerals, as they occur in but few species, and in these rare cases the same physical properties are met with in very different species. The principal physical characters which occur among minerals, are Electricity, Magnetism, and Phosphorescence.

1. *Electricity.*

It is well known that there are two kinds of electricity; the one named *positive* or *vitreous*, and the other *negative* or *resinous*.

Electricity can be excited in minerals in three different ways,—by friction, by heating, or by communication with an electrified body. The greater number of minerals which are capable of becoming electrical, acquire this property by friction. Earthy, saline, and metallic minerals, in this way become positively electrified. Some minerals by this process become very easily and powerfully electric, while others become electric with difficulty, and exhibit but faint traces of it. A few minerals become electric by heating, and these belong to the number that also exhibit electrical properties by friction. It has been ascertained, that these minerals have at least two points, of which the one is the seat of positive, and the other that of negative electricity. To these points, which are always placed in two opposite parts of the mineral, Hauy gives the name of *electric poles*. For a full account of the pyro-electricity of minerals, see the article ELECTRICITY.

The third mode of exciting electricity in minerals, or that by communication, occurs only in minerals which are in a pure metallic state.

2. *Magnetism.*

Very few minerals are magnetic; it is a character which occurs principally in ores of iron, or in such minerals as contain a portion of metallic iron, or iron in the state of black oxide. A good many minerals, after exposure to the blow-pipe, become magnetic.

3. *Phosphorescence.*

Some minerals, when rubbed or heated emit in the dark a more or less shining light, are said to be phosphorescent. Thus, yellow blende, when scratched with a hard body, emits a strong light. When two pieces of quartz are forcibly struck against each other, both become luminous; and fluor-spar, and other minerals, when heated, become phosphorescent. For a full account of phosphorescent minerals, by Dr. Brewster, see the *Edinburgh Philosophical Journal*, vol. i. p. 383.

Geognostical and Geographical Characters.

These characters are derived from the geognostical relations and geographical distribution of the species. In another article we shall show that simple minerals are not irregularly distributed throughout the crust of the earth. On the contrary, that particular species very often occur together, and in the same formation; that some species are met with in nearly all the formations of rocks, others in only a few members of the series, while some are confined to a particular rock; and that certain beds and formations are characterized by the simple minerals they contain. In their geographical distribution, numerous interesting relations will be pointed out, of the grouping of particular species in limited tracts of country; of the wider range of others through whole regions; and of the distribution of species, according to distance from the equator, and particular meridians.

Mohs' Crystallography.

The preceding details make us acquainted with those characters which are used in *describing* minerals; but in the following arrangement considerable use is made of the primitive forms, as ascertained by Professor Mohs. According to his view, every simple form, from which other simple forms are derived, is named a *fundamental form*; and the class of figures derived from that fundamental form, *a system of crystallizations.* The fundamental forms are four in number, and, consequently, also the systems of crystallization. These fundamental forms are, the *rhomboid*, *pyramid with a square base*, *oblique four-sided prism*, and *hexahedron* or *cube*; and the systems of crystallizations derived from these, are denominated *rhomboidal. pyramidal, prismatic*, and *tessular*. Connected with the rhomboids there are series of *scalene six-sided pyramids*; and the series both of rhomboids and of the scalene pyramids are terminated by *regular six-sided prisms*, which are distinguished from each other by their positions. The pyramids with square bases form series; and their limiting form, or last member of the series, is the *rectangular four-sided prism*. Each pyramid with a square base has *depending* on it three *scalene eight-sided pyramids*; and the limiting forms of these scalene eight-sided pyramids are *unequiangular eight-sided prisms*. The oblique four-sided prism has depending on it numerous oblique based pyramids, and oblique prisms. The hexahedron has depending on it the *regular octahedron*, including the *tetrahedron*, the *rhomboidal dodecahedron*, and the *icositetrahedron*. The forms that arise from the hexahedron produce among themselves various combinations; but they admit into them no form, *which is either a rhomboid, or a four-sided pyramid with a square base, or an oblique four-sided pyramid, or can be derived from any of these figures.* The rhomboid, the four-sided square-based pyramid, and the

* These Observations on the action of the Blowpipe are taken from Mr. Aikin's Manual, p. 35.

four-sided oblique-based pyramid, are forms which cannot by any means be derived from each other; hence the *four groups* of simple forms, as well as their combinations, must each be altogether distinct from the rest; and hence arises a correct and natural division of all *possible* crystallizations, which is of great utility in mineralogy. An interesting sketch of Mohs' Views in Crystallography, is given in the *Edinburgh Philosophical Journal*, vol. iii. p. 154. Fig. 10. Plate CCCXCVI. represents the *rhomboid;* Fig. 30, *Pyramid with square base;* Fig. 6, *Oblique four-sided prism;* Fig. 3, *Hexahedron* or *cube;* Fig. 9, *Tetrahedron;* Fig. 2, *Pentagonal Dodecahedron;* and Fig. 35, the *Tetragonal isositetrahedron.*

The nomenclature of the species used is nearly that of Mohs, and is founded on the primitive forms of the minerals, on the nature of their cleavage, or on the position of the bevelment.

According to Mohs, as already mentioned, all the regular forms in the mineral kingdom are reducible to some one of four great systems or groups, named Rhomboidal, Pyramidal, Prismatical, and Hexahedral or tessular, including octahedron, cube octahedron, rhomboidal dodecahedron, &c. Thus, in the genus Corundum, there are three species in which the primitive forms are the octahedron, rhomboid, and prism; and hence these are named octahedral corundum, rhomboidal corundum, and prismatic corundum. In the genus Zeolite, there are seven species; one of these is named Prismatoidal zeolite, because the cleavage is prismatoidal; another is named Axifrangible, because one of its most striking characters is its axifrangible cleavage. In the genus Augite, one species is named Oblique-edged augite, because the edge formed by the meeting of the bevelling planes, on the extremities of the crystal, is placed obliquely to the axis of the prism; another species is named Straight-edged augite, because the edge formed by the bevelling planes on the extremity, is straight or perpendicular to the axis of the prism.

In the generic characters, the number of axes of the crystals is given. But it will be inquired, what is here understood by axis. When the section of a simple figure, as a rhomboid or cube, affords, by means of a plane which does not pass through its centre, a regular, or equi-angular or equi-lateral figure, or one in which such a figure can be inscribed, the straight line, which stands perpendicular on the middle point of the figure, and passes through the centre of the figure, is an *axis.* If we take a hexahedron, and place it in such a situation that two only of its planes are horizontal, and the others vertical, every section of it, with a horizontal plane, will afford a square; and the vertical line, which stands perpendicular on the middle point of the square, and passes through the centre of the figure itself, will be an axis. Bring the same hexahedron in such a situation, that one of its solid angles is above, and another vertically under it. The section with a horizontal plane will be an equilateral triangle or equi-angular hexagon, and the straight line perpendicular on the middle point of this plane, and through the centre of the figure, an axis. Lastly, if we place the hexahedron in such a situation, that four of its edges are horizontal, and the others are equally inclined towards the horizontal plane, all the sections but two will be longish rectangles, and the straight line, perpendicular on the middle point, and through the centre of the figure, is an axis.—The kind of axis is determined by the figure of the section, and one and the same figure may contain not only many, but also axes of different kinds. That axis in which the form of the section is triangular, or in which a triangle can be inscribed by connecting some of its angles by straight lines, is named a *rhomboidal axis,* because it occurs in the rhomboid; when the form of the section is a square, the axis is named *pyramidal,* because it occurs in the pyramid with square bases; and when the form of the section is rhomboidal, the axis is named *prismatic,* because it occurs in the oblique double four-sided prism, which is a member of the prismatic series. In the Tabular View, the Diamond is said to have *many axes,* because its primitive figure, the octahedron, has rhomboidal axes that pass through the centre of the planes, pyramidal axes that pass through the angles, and six subordinate axes that pass through the middle point of the edges. Zircon is said to have one axis, because its primitive figure belongs to the pyramidal system, in which there is only one principal axis. Topaz has three axes, because it belongs to the prismatic series, in which there are three principal axes.

II. SYSTEM OF ARRANGEMENT.

Three modes of arranging simple minerals have been employed by naturalists: in the first, they are arranged according to their chemical composition; in the second, in conformity with their external characters; and in the third, both methods are conjoined. The pure chemical method is desirable in a system of chemistry: the mixed method, from its unsatisfactory nature, should be banished from mineralogical science; while that founded on external characters, or what has been called the Natural History Method, ought to be adopted as the only true and scientific plan for the purposes of natural history and practical utility. The natural history method is followed in the present article, and the arrangement is that of Professor Mohs of Freyberg. Dr. Walker, the former Professor of Natural History in the University of Edinburgh, taught mineralogy according to the natural history method. Professor Jameson, his successor, has frequently done the same; and we find, from the introduction to the third edition of his *System of Mineralogy,* that he now abandons the mixed method, and adopts the natural history method.

The following is a tabular view of the plan of arrangement followed of the genera and species now to be described.

CLASS I.

ORDER I. GAS.

Genus 1. Marsh gas. Sp. 1. Carburetted.
2. Sulphuretted.
3. Phosphuretted.

Genus 2. Meteoric gas. Sp. 1. Pure gas or atmospherical air.

ORDER II. WATER.

Genus 1. Meteoric water. Sp. 1. Pure water.
2. Sea water. 1. Common.

ORDER III. ACID.

Genus 1. Carbonic acid. Sp. 1. Æriform.
2. Muriatic acid. 1. Æriform.

3. Sulphuric acid.	1. Æriform.
	2. Fluid.
4. Boracic acid.	1. Scaly.
Genus 5. Arsenic acid.	1. Octahedral.

ORDER IV. SALINE MINERALS.

Genus 1. Natron.	Sp. 1. Prismatic.
2. Nitre.	1. Prismatic.
3. Glauber salt.	1. Prismatic.
4. Alum.	1. Octahedral.
5. Epsom salt.	1. Prismatic.
6. Vitriol.	1. Rhomboidal.
	2. Prismatic.
	3. Pyramidal.
7. Sal ammoniac.	1. Octahedral.
8. Rock salt.	1. Hexahedral.
9. Borax.	1. Prismatic.

CLASS II.

ORDER I. HALOIDE.

Genus 1. Gypsum.	Sp. 1. Axifrangible or common.
	2. Prismatic or anhydrite.
2. Cryolite.	1. Pyramidal.
3. Alum-stone.	1. Rhomboidal.
4. Fluor.	1. Octahedral.
5. Apatite.	1. Rhomboidal.
6. Limestone.	1. Prismatic or arragonite.
	2. Rhomboidal or calcareous spar, &c.
	3. Short axed. Dolomite and rhomb spar in part.
	4. Long axed. Rhomb spar in part.

ORDER II. BARYTE.

Genus 1. Red manganese.	Sp. 1. Rhomboidal.
2. Sparry iron.	1. Sparry iron.
3. Calamine.	1. Prismatic.
	2. Rhomboidal.
4. Tungsten.	1. Pyramidal.
5. Baryte.	1. Di-prismatic or Strontianite.
	2. Rhomboidal or Witherite.
	3. Prismatic or common.
	4. Axifrangible or celestine.
6. Lead spar.	1. Di-prismatic or white lead spar.
	2. Rhomboidal, or green and brown lead spar.
	3. Prismatic, or red lead spar.
	4. Pyramidal, or yellow lead spar.
	5. Tri-prismatic, or lead vitriol.

ORDER III. KERATE.

Genus 1. Corneous silver.	Sp. 1. Hexahedral.
2. Corneous Mercury.	1. Pyramidal.

ORDER IV. MALACHITE.

Genus 1. Copper green.	Sp. 1. Common.
2. Malachite.	1. Prismatic, or blue copper.
	2. Acicular, or common malachite.
Genus 3. Olivenite.	Sp. 1. Prismatic, or phosphate of copper.
	2. Di-prismatic, or lenticular copper.
	3. Acicular.
	4. Hexahedral, or cube ore.
4. Emerald-copper.	1. Rhomboidal.

ORDER V. MICA.

Genus 1. Copper mica.	Sp. 1. Prismatic.
2. Uran mica.	1. Pyramidal.
3. Cobalt mica.	1. Prismatic or red cobalt.
4. Antimony mica.	1. Prismatic or red antimony.
5. Blue iron, or iron mica.	1. Prismatic.
6. Graphite.	1. Rhomboidal.
7. Mica.	1. Rhomboidal, including mica, chlorite, talc, &c.
8. Pearl mica.	1. Rhomboidal.

ORDER VI. SPAR.

Genus 1. Schiller spar.	Sp. 1. Prismatic, or green diallage.
	2. Slaty, including bronzite and common schiller spar.
	3. Labrador, or hyperstene.
	4. Gerader, or anthophyllite.
Genus 2. Kyanite.	Sp. 1. Prismatic.
3. Spodumene.	1. Prismatic.
4. Prehnite.	1. Prismatic.
5. Datolite.	1. Prismatic.
6. Zeolite.	1. Dodecahedral, or leucite.
	2. Hexahedral, or analcime.
	3. Rhomboidal, or chabasite.
	4. Pyramidal, or cross-stone.
	5. Di-prismatic, or Laumonite.
	6. Prismatic, or mesotype.
	7. Prismatoidal, or stilbite.

Zeolite.	Sp. 8. Axifrangible, or apophyllite.
7. Felspar.	Sp. 1. Rhomboidal or nepheline.
	2. Prismato-pyramidal, or meionite.
	Sp. 3. Prismatic, or common.
	4. Pyramidal, or scapolite.
8. Augite.	Sp. 1. Oblique-edged, including common augite, diopside, &c.
	2. Straight-edged, including hornblende, actynolite, and asbestus.
	3. Prismatoidal, or epidote.
	4. Prismatic, or tabular spar.
9. Azure spar.	Sp. 1. Prismatic, including azurite and Hauyne.
	2. Prismatoidal, or blue spar.

ORDER VII. GEM.

Genus 1. Boracite.	Sp. 1. Octahedral.
2. Andalusite.	1. Prismatic.
3. Corundum.	1. Octahedral, or spinel.
	2. Rhomboidal. Oriental ruby and sapphire.
	3. Prismatic, or chrysoberyl.
4. Diamond.	1. Octahedral.
5. Topaz.	1. Prismatic.
6. Emerald.	1. Rhomboidal.
	2. Prismatic, or euclase.
7. Quartz.	1. Rhomboidal.
	2. Indivisible.
8. Axinite.	1. Prismatic.
9. Chrysolite.	1. Prismatic.
10. Tourmaline.	1. Rhomboidal.
11. Garnet.	1. Pyramidal, or Vesuvian.
	2. Dodecahedral, including precious garnet, &c.
	3. Prismatic, or grenatite.
12. Zircon.	1. Pyramidal.
13. Gadolinite.	1. Prismatic.

ORDER VIII. ORE.

Genus 1. Titanium ore.	Sp. 1. Prismatic, or sphene.
	2. Prismato-pyramidal, including rutile, iserine, and menachanite.
	3. Pyramidal, or octahedrite.
2. Red copper ore.	1. Octahedral.
3. Tin ore.	1. Pyramidal or tin-stone.
4. Wolfram, or scheel ore.	1. Prismatic.
5. Tantalum ore.	1. Prismatic.
6. Uranium ore.	1. Indivisible.
7. Cerium ore.	1. Indivisible.
8. Chrome ore.	1. Prismatic.
9. Iron ore.	1. Octahedral, or magnetic ore.
	2. Rhomboidal, red iron-ore, or iron-glance.
	3. Prismatic, or brown iron-ore.
10. Manganese ore.	1. Prismatic, or grey and black manganese ores.

ORDER IX. NATIVE METALS.

Genus 1. Arsenic.	Sp. 1. Native.
2. Tellurium.	1. Native.
3. Antimony.	1. Dodecahedral, or native antimony.
	2. Octahedral, including antimonial and arsenical silver.
4. Bismuth.	Sp. 1. Octahedral.
5. Mercury.	1. Dodecahedral, or amalgam.
	2. Fluid.
6. Silver.	1. Hexahedral.
7. Gold.	1. Hexahedral.
8. Platina.	1. Native.
9. Iron.	1. Octahedral.
10. Copper.	1. Octahedral.

ORDER X. PYRITES.

Genus 1. Nickel pyrites.	Sp. 1. Prismatic, or copper nickel.
2. Arsenical pyrites.	1. Prismatic.
	2. Di-prismatic.
3. Cobalt pyrites.	1. Hexahedral, or silver-white cobalt.
	2. Octahedral, or tin-white and grey cobalt.
4. Iron pyrites.	1. Hexahedral.
	2. Prismatic.
	3. Rhomboidal.
5. Copper pyrites.	1. Octahedral, or yellow copper pyrites.
	2. Tetrahedral, including grey and black copper pyrites.

ORDER XI. GLANCE.

Genus 1. Copper glance.	Sp. 1. Rhomboidal.
2. Silver glance.	1. Hexahedral.
	2. Rhomboidal.
3. Lead glance, or galena.	1. Hexahedral.
4. Black tellurium.	1. Prismatic.
5. Molybdena.	1. Rhomboidal.
6. Gold glance.	1. Prismatic.
7. Bismuth glance.	1. Acicular.
	2. Prismatic.
8. Antimony glance.	1. Prismatoidal, or grey antimony.
	2. Axifrangible, or Bournonite.
	3. Prismatic.

ORDER XII. BLENDE.

Genus 1. Manganese blende.	Sp. 1. Prismatic.
2. Zinc blende, or garnet blende.	1. Dodecahedral.
3. Antimony blende.	1. Prismatic, or red antimony.
4. Ruby blende.	1. Rhomboidal, or red silver.
	2. Prismato-rhomboidal, or cinnabar.

ORDER XIII. SULPHUR.

Genus 1. Sulphur.	Sp. 1. Hemi-prismatic, or ruby-sulphur, or red orpiment.
	2. Prismatoidal sulphur, or yellow orpiment.
	3. Prismatic, or common sulphur.

CLASS III.

ORDER I. RESIN.

Genus 1. Honey-stone.	Sp. 1. Pyramidal.
2. Mineral resin.	1. Yellow or amber.
	2. Black, including mineral oil and mineral pitch.

ORDER II. COAL.

Genus 1. Coal.	Sp. 1. Brown coal.
	2. Black coal.
	3. Glance coal.

When we wish to determine the species to which any mineral belongs, by means of the preceding system, we first ascertain either its primitive form or cleavage, and afterwards the hardness and specific gravity. We next compare these characters with those in the Classes, Orders, Genera, and Species; and if a species in any of the genera possesses the same characters, our mineral is to be considered as belonging to that species.

If the form or cleavage cannot be ascertained, our determination of the species will not be so satisfactory or certain. Thus, suppose we meet with a variety of iron pyrites, in which neither form nor cleavage can be detected, but of which the hardness and specific gravity are known; and that the hardness is 6, and the specific gravity 4.9. If we compare these characters with those of the Classes, Orders, Genera, and Species, we shall find that the only genus to which they apply, is *iron pyrites*. But these characters will not enable us to determine the species with absolute certainty, because the essential character of every species depends on the primitive form. They will, however, show that the mineral is iron pyrites, even that it is not rhomboidal iron pyrites; but they will not enable us to decide whether it is hexahedral or prismatic iron pyrites. In other cases, the species can be determined without knowing the primitive form; but still, the determination is not so certain as when that form is known. Thus, suppose we meet with a species of magnetic iron ore, which we find, by inspection, cannot be either the rhomboidal or prismatic species, but which agrees in hardness and specific gravity with the octahedral species, we can say that it very probably is a variety of octahedral magnetic ore. But there may be a fourth species of this genus not in the system, having the same hardness and specific gravity as the octahedral, but with a different primitive form; and we cannot be certain that our mineral does not belong to that species. When the primitive form is known, all doubt vanishes. In compound minerals, it is very often impossible to determine the external form. In such cases, a knowledge of the cleavage is of infinite importance. But when neither form, nor hardness, nor specific gravity, can be determined, the system cannot be advantageously used; for the principal characters on which it depends are wanting. Amianthus, which is a variety of straight-edged augite, (hornblende,) occurs in crystals so very minute, that they cannot be determined either by the eye or the microscope, and of course the cleavage is not visible. These crystals are flexible, and their hardness not capable of being determined. Their surface is so considerable in comparison of their mass, that they float on water, although they have a considerable specific gravity. It is remarked, that in other varieties of straight-edged augite, the crystals become thicker, then lose their flexibility, but are still too small for allowing the hardness to be ascertained; others, again, are thicker, but still, owing to their minuteness, the dimensions of the form cannot be measured; these sink in water, scratch gypsum, but break on calcareous spar. At last, in other varieties, the form is discernible by the cleavage, and the hardness is equal to 5 and 6. and the specific gravity equal to 3.0. These, on examination, prove to be straight-edged augite. What these are, so are all the preceding varieties, and also amianthus. It is by pursuing this mode of examination, that we are able to refer such substances as amianthus to their true place in the system. Other minerals, again, which occur in an earthy state, can only be referred to their true place in the system by tracing them in connection with compact minerals, which stand in connection with others having a crystallised structure. Thus porcelain earth can be traced to compact felspar, and this to foliated felspar; or it can be traced immediately to foliated felspar, and in this way its true place is ascertained. Other earths, and loosely aggregated minerals, as many clays, cannot be referred to any species; these, therefore, are determined in an empirical way; and we may use the blowpipe, acids, and other means, for obtaining a knowledge of their properties. These bodies are more properly objects of geological curiosity, and of economical value, than interesting to the mineralogist.

The nomenclature of the species used in the present arrangement, is founded on the primitive forms of the minerals, on the nature of their cleavage, or on the position of the bevelment.

According to Mohs, all the regular forms in the mineral kingdom are reducible to some one of four great systems or groups, named rhomboidal, pyramidal, prismatical, and hexahedral or tessular, including octahedron, cube, rhomboidal dodecahedron, &c. Thus, in the genus corundum, there are three species, in which the primitive forms are the octahedron, rhomboid, and prism; and hence these are named, octahedral corundum, rhomboidal corundum, and prismatic corundum. In the genus zeolite, there are seven species; one of these is named prismatoidal zeolite, because the cleavage is prismatoidal; another is named axifrangible, because one of its most striking characters is its axifrangible cleavage. In the genus augite, one species is named oblique-edged augite, because the edge formed by the meeting of the bevelling planes, on the extremities of the crystal, is placed obliquely to the axis of the prism; another species is named straight-edged augite, because the edge formed by the bevelling planes on the extremity, is straight or perpendicular to the axis of the prism.

CLASS I.

If solid, there is a sensible taste. No bituminous smell. Specific gravity under 3.0.

Order I. GAS.

Æriform. Not acid. Sp. gr. = 0.0001.—0.0014.

Genus I. MARSH GAS.

Smell. More or less respirable. Sp. gr. = 0,0001.—0,0014.

This genus contains three species, viz. 1. Carburetted marsh gas. 2. Sulphuretted marsh gas. 3. Phosphuretted marsh gas.

1. Carburetted marsh gas, or carburetted hydrogen. Empyreumatic smell. Sp. gr. = 0,0008.

Geognostic Situation.—This gas rises from marshes and volcanoes. It is also met with in great quantities in coal-mines, forming the *fire-damp* of miners.

2. Sulphuretted marsh gas, or sulphuretted hydrogen. Smell of rotten eggs. Taste nauseous and bitter.

Hydrogen 6.244. Sulphur 93.756 = 100. *Berzelius.*

Geognostic Situation.—It rises from sulphureous springs, also from marshy places, and is met with in mines.

3. Posphuretted marsh gas, or posphuretted hydrogen. Smell of putrid fish. Taste bitter.

Geognostic Situation.—It rises from marshy and other places where organic substances are in a state of decomposition.*

Genus II. METEORIC GAS.

Without smell or taste. Perfectly respirable. Sp. gr. =0.001.—0.0013—

1. Pure meteoric gas, or atmospheric air. Respirable, without smell or taste.

Geognostic Situation —Forms the atmosphere which surrounds the earth.

Order II. WATER.

Fluid. Tasteless, or with sensible taste and smell. Sp. gr. = 1 1—1,0269.

Genus I. METEORIC WATER.

Without smell or taste.

1. Pure. Without smell or taste.

This is common rain, river, and spring water. Mineral waters are to be considered as accidental varieties of pure meteoric water.

Genus II. SEA WATER.

Sensible taste and smell.

1. *Common.* Bitter nauseous taste and disagreeable smell.

Order III. ACIDS.

If solid, is feebly acid. If the Sp. gr. is = 3 and more, it is sweetish astringent. Sp. gr. =0.0015—3.7.

Genus I. CARBONIC ACID.

Spiritus Letalis, *Plin.* Gas Sylvestre, Spiritus Sylvestris, *Paracelsus* and *Van Helmont.* Fixed air, *Black.*

Taste acid. Sp. gr. =0.0018.

1. *Æriform.* Is gaseous.

Geognostic and Geographic Situations.—It occurs in considerable quantities in marshy places, rises from certain acidulous waters, and abounds in many caves, as in that of Del Cane near Naples, and of Aubenas in Ardèche.

Genus II. MURIATIC ACID.

Smell of saffron and strong acid taste. Not respirable. Sp. gr. =0.0023.

1. *Æriform.* In the gaseous form.

Geognostic Situation.—Emanates from volcanoes, &c.

Genus III. SULPHURIC ACID.

If æriform, the smell is sulphureous, and it is not respirable; if fluid it is strongly acid to the taste. Sp. gr. =0,0025—1.5.

1. Æriform. Sp. gr. =0.0025.

Geognostic Situation.—It rises from volcanoes, and sometimes in considerable quantity.

2. *Fluid.* Fluid. Sp. gr. =1.4—1.5.

Geognostic and Geographic Situations.—It is observed trickling from the roofs of caves in Ætna; near Aix, in Savoy, and in various places in Italy. Also in some situations in America, and in the island of Java.

Genus IV. BORACIC ACID.

Solid. Sp. Gravity under 3.0.

1. *Scaly.* It occurs in scaly crusts. It tastes first sourish, or subacid, then bitter and cooling, and lastly sweetish.

Geognostic and Geographic Situation.—It is found on the edges of hot springs, near Sasso, in the territory of Florence, and also in Volcano, one of the Lipari islands.

Genus V. ARSENIC ACID.

Solid. Specific gravity above 3.

1. *Octahedral.* Cleavage octahedral. Taste sweetish astringent. Sp. gr. =3.6—3.7.

External Characters.—Its colours are reddish-white, snow-white, yellowish-white, and milk-white. It occurs massive, in thin crusts, stalactitic, small reniform, and botryoidal; and frequently in delicate capillary shining crystals, which are scopiformly or stellularly aggregated. Its lustre is shining and silky, and pearly. It is very soft, passing into friable.

Chemical Character.—Is soluble in water.

Geognostic and Geographic Situation.—It occurs as a secondary formation in veins, as at Andreasberg in the Hartz, where it is accompanied with native arsenic, red silver, galena, and red orpiment.

Order IV. SALTS.

olid. Not acid, but subacid. Sp. gr.=.

* Hydrogen gas, in a pretty pure state, forms the material of the perpetual fires of some countries, and might here be introduced as a distinct species of marsh gas.

Genus I. NATRON.

Cleavage prismatic. Taste sharp and alkaline. H.=. Sp. gr. =1.4.

1. Prismatic Natron.—*Jameson.*

Prism =129° 60°? Cleavage not accurately ascertained.

This species is divided into two subspecies, viz. Common natron and radiated natron.

First Subspecies.

Common Natron, *Jameson.*—Gemeines Natron, *Werner.*

Description.—External Characters.—Colours, yellowish and greyish-white; also smoke grey and cream-yellow. When fresh, it is compact, sometimes granular, sometimes radiated, vitreous and glistening, and more or less translucent: when weathered, it is in loose, dull, opaque parts.

Chemical Characters.—It effervesces with acids. It is easily soluble in water, and its solution colours blue vegetable tinctures green. It is very fusible before the blowpipe.

Constituent Parts.

Egyptian Natron.		*Bohemian Natron.*		*Natron of Hungary.*	
Dry sub-carbonate of Soda,	32.6	Carbonate of Soda, -	89.18	Carbonate of Soda, -	14.2
Dry Sulphate of Soda, -	20.8	Carbonate of Lime, -	7.44	Muriate of Soda,	22.4
Dry Muriate of Soda, -	15.0	Carbonate of Magnesia, -	1.35	Sulphate of Soda, -	9.2
Water, -	31.6	Extractive matter. -	2.03	Earthy residuum,	9.2
				Water, -	45.0
	100.0		100.00		100.0
Klaproth, Beit. b. iii. s. 80.		*Reuss.* Min. b. iii. s. 5.		According to *Lampadius.*	

Geognostic Situation.—It occurs as an efflorescence on the surface of soil,—on decomposing rocks of particular kinds,—on the sides and bottoms of lakes that become dry during the summer season,—also on the walls and bottoms of caves,—and dissolved in the water of lakes and springs. In Hungary, according to Ruckert and Pazmand, there are so many natron lakes, that 50,000 quintals of soda could be obtained from them annually. In some places of the same country, it effloresces on the surface of the soil, heath, &c. It abounds in the natron lakes of Egypt.

Geographic Situation.—Europe.—It occurs in Bohemia, Hungary, Switzerland, in the Phlegrean Fields, Monte Nuovo, near Naples, and Mount Ætna in Sicily.

Africa.—It occurs in considerable quantity in Egypt.

Asia.—In the vicinity of Smyrna, and the ancient city of Ephesus; in Bengal; near Bombay; Persia; Natolia; district of Ochotsk, in the government of Irkutsk; and in the Crimea.

America.—Dissolved in the lakes of Mexico.

Second Subspecies.

Radiated Natron, *Jameson.*—Strahliches Natron, *Klaproth.*

External Characters.—Colours greyish and yellowish white. Occurs in crusts, in radiated distinct concretions, and crystallized in capillary or acicular crystals, which are aggregated on one another. The lustre is glistening and vitreous. It is translucent.

Chemical Characters.—Same as those of common natron.

Constit. Parts.—Water of crystallization, 22.50
Carbonic acid, . 38 00
Pure soda, . . 37.00
Sulphate of soda, . 2 50—100.00
Klaproth, Beit. b. iii. s. 87.

Geognostic and Geographic Situations.—Mr. Bagge, Swedish Consul at Tripoli, gives the following information respecting this interesting subspecies of natron. "The native country of this natron, which is there called *Trona*, is the province Sukena, two days journey from Fezzan. It is found at the bottom of a rocky mountain, forming crusts, usually the thickness of a knife, and sometimes, although rarely, of an inch, on the surface of the earth. It is always crystalline: in the fracture it consists of cohering, longish, parellel, frequently radiated crystals, having the aspect of unburnt gypsum. Besides the great quantity of trona which is carried to the country of the Negros and to Egypt, fifty tons are annually carried to Tripoli. It is not adulterated with salt. The salt-mines are situated on the sea-shore; but the trona occurs twenty-eight days journey up the country." According to the accounts of Mr. Barrow, it would appear also to occur in the district of Tarka, in Boshieman's Land, in Southern Africa.

Uses.—It is principally employed in the manufacture of glass and soap, in dyeing, and for the washing of linen. It is sometimes purified before it is used, but more frequently (particularly that from Egypt) it is used in its natural state.

Genus II. NITRE.

Three axes. Cleavage, prismatic. Taste, cooling and saline. Hardness = 2.0. Specific gravity = 1.9, 2.0.

1. Prismatio Nitre, *Jameson.*—Prismatisches Natürlicher Saltpeter, *Mohs.* Natürlicher Salpeter, *Werner.*

Prism = . Cleavage prismatic, and in the direction of the smaller diagonal of the prism.

Description.—External Characters.—Colours greyish-white, yellowish-white, and snow-white. Occurs in flakes, crusts, and in capillary prismatic crystals. Dull, glimmering, or shining, and the lustre vitreous. Alternates from translucent to transparent. Brittle, and easily frangible.

Chemical Characters.—Deflagrates when thrown on hot coal.

Constituent Parts.—The natural nitre of Molfetta, according to Klaproth: Nitrate of potash, 42.55
Sulphate of lime, 25.45
Carbonate of lime, 30.40
Muriate of Potash? 0.20
Loss, . . 1.40
——100.00
Klaproth, Beit. b. i. s. 320.

Geognostic Situation.—It is usually found in thin crusts on the surface of soil, and sometimes also covering the surface of compact limestone, chalk, and calc-tuff. In many countries it germinates in certain seasons out of the earth, and when this earth is accumulated in heaps, so as to expose a large surface to the atmosphere, it is found to produce it annually.

Geographic Situation.—Europe.—It is found in great quantities in many plains in Spain; very abundantly in the plains of Hungary, the Ukraine and Podolia; and also in France and Italy.

Asia.—Nitre is very abundant in India; also in Persia; and in the valley between Mount Sinai and Suez, in Arabia.

Africa.—This salt is abundant in Egypt; also at Ludamar, in the interior of Africa; and in the Karoo Desart. to the east of the Cape of Good Hope.

America.—The nitre used for the manufacture of gunpowder in the United States of America, is obtained from an earth collected in the limestone caves of Kentucky. Nitre effloresces in considerable abundance on the soil near Lima; and in Tucuman in South America.

Uses.—In Hungary, Spain, Molfetta, and the East Indies, considerable quantities of natural nitre are collected; but the greatest proportion of that used in commerce, is obtained by working artificial nitre beds. These consist of the refuse of animal and vegetable bodies, undergoing putrefaction, mixed with calcareous and other earths. Its principal use is in the fabrication of gunpowder: it is also used in medicine, and many of the arts.

Genus III.—GLAUBER SALT.

Three axes. Cleavage prismatic. Taste first cooling, and then saline and bitter. Hardness = . Sp. gravity 2.2, 2.3.

1. Prismatic Glauber Salt, *Jameson.*—Prismatisches Glauer Salz, *Mohs.* Natürliches Glauber Salz, *Werner.*

Prism unknown. Cleavage not accurately ascertained.

External Characters.—Its colours are greyish and yellowish white; seldom snow or milk white. It occurs in the form of mealy efflorescences; in crusts; seldom stalactitic, small botryoidal, reniform; in small and fine granular distinct concretions; and crystallized in prisms, which are often acicular. Internally it is shining, and the lustre is vitreous. The fracture is conchoidal, or uneven. The fragments are indeterminately angular, and blunt edged. It is brittle, and easily frangible.

Chemical Characters.—Before the blowpipe, it is affected in the same manner as Epsom salt, but its solution does not, like that of Epsom salt, afford a precipitate with an alkali.

Constituent Parts.—Natural Glauber Salt of Eger, according to Reuss, (Chemische-medicinische Breschreibung des Kaiser Franzens Bades, Dresden, 1794), contains

Sulphate of Soda,	67.024
Carbonate of Soda,	16.333
Muriate of Soda,	11.000
Carbonate of Lime,	5.643——100

Geognostic Situation.—It occurs, along with rock-salt and Epsom salt, on the borders of salt lakes, and dissolved in the waters of lakes; in efflorescences on moorish ground; also on sandstone, marl-slate, and old and newly built walls.

Geographic Situation.—*Europe.*—It occurs in Germany, France, Hungary, Spain, and Italy.

Asia.—It occurs on the banks, and in the water of many Siberian salt-lakes; neighbourhood of the Lake Baikal; the desert plains of Iset, Ischem, and Barebyn.

Africa.—Egypt.

Uses.—It is used as a purgative medicine; and in some countries as a substitute for soda, in the manufacture of white glass.

Genus IV. ALUM.

Many axes. Cleavage tessular. Taste sweetish, astringent and acidulous. Hardness = 2.0,25. specific grav. = 1.7, 1.8.

1. Octahedral Alum, *Jameson.* Octaedrisches Alaun, *Mohs.* Natürlicher Alaun, *Werner.*

Crystallized in tubes and octahedrons. Cleavage octahedral.

External Characters.—Colours yellowish and greyish-white. Occurs as a farinaceous efflorescence, stalactitic, in delicate curved and parallel fibrous concretions. The varieties with fibrous concretions have a pearly lustre; others are glistening and vitreous. When the fracture can be observed, it is conchoidal.

Chemical Characters.—It is soluble in from sixteen to twenty times its weight of water. It melts easily by means of its water of crystallization; and by continuance of the heat, it is converted into a white spongy mass.

Constituent Parts.—

	Natural Alum of Freinwald.
Alumina,	15.25
Potash,	0.25
Oxide of iron,	7.50
Sulphuric acid, and water,	77.00—100.00

Klaproth, Beit. b. iii. s. 103.

Geognostic Situation.—It generally occurs as as efflorescence on aluminous minerals, as alum-slate, alum-earth, alum-stone, aluminous coal, aluminous-slate-clay, and bituminous shale, and also encrusting lavas.

Geographic Situation.—*Europe.*—It occurs as an efflorescence on the surface of bituminous-shale and slate-clay at Hurlet, near Paisley; also encrusting alum-slate near Moffat, in Dumfriesshire; Ferrytown of Cree, in Galloway; and at Whitby, in Yorkshire. On the Continent of Europe, it is met with in many places, as in the alum-slate rocks near Christiania in Norway; in coal-mines in Bohemia; also in Austria, Bavaria, Hungary, Italy, and the Islands of Stromboli, Milo, &c. in the Mediterranean Sea.

Africa.—In Egypt.

America.—In Real del Monte in Mexico, on a porphyritic stone.

Uses.—It is employed as a mordant in dying; also in the manufacture of leather and paper; as a medicine; for preserving animal substances from putrefaction; and it is sometimes mixed with bread, in order to give it a whiter colour.

* Rock-Butter (*a.*)—Bergbutter, *Werner.*

External Characters.—Colours yellowish-white, yellowish-grey, cream-yellow, straw-yellow and pale sulphur-yellow. Occurs massive, and tuberose. Internally strongly glimmering, and resinous. Fracture straight foliated. Fragments blunt-edged. Translucent on the edges. Feels rather greasy. Easily frangible.

Constituent Parts.—It is alum, mixed with alumina and oxide of iron.

Geognostic Situation.—It oozes out of rocks that contain alum, or its constituents, as alum-slate, bituminous-shale impregnated with iron-pyrites, or alum-earth.

Geographic Situation.—It occurs at the Hurlet alum-work, near Paisley; oozing out of rocks of alum-slate in the island of Bornholm, in the Baltic; at Muskau in

Upper Lusatia; Saalfeld in Thuringia; and, according to Pallas, in aluminous rocks on the banks of the river Jenisei, in Siberia.

Genus V. EPSOM SALT.

Three axes. Cleavage prismatic. Taste bitter and saline. Hardness = . spec. grav. =

1. Prismatic Epsom Salt, *Jameson.*—Prismatisches Bitter Salz, *Mohs.*—Natürlicher Bitter Salz, *Werner.*

Prism. = 90°. Cleavage very perfect, according to one of the diagonals.

External Characters.—Colours snow-white, greyish-white, yellowish-white, sometimes ash-grey, and smoke-grey. Occurs in farinaceous crusts, flakes, small botryoidal, reniform, and crystallized. Prisms acicular and capillary. The farinaceous variety is dull, the others shining, glistening, and pearly. Varies from transparent to opaque. Brittle, and easily frangible.

Chemical Characters.—Before the blowpipe, it dissolves very easily by the assistance of its water of crystallization, but it is difficultly fusible. Its solution gives a precipitate with lime-water.

Constituent Parts.—The constituent parts of purified Epsom salt, the sulphate of magnesia of chemists, are, according to

	Bergmann.	*Kirwan.*
Sulphuric Acid, .	33.0	29.46
Magnesia, . . .	19.0	17.00
Water of Crystallization,	48.0—100.0	53.54—100.00

Geognostic and Geographic Situations.—It occurs as an efflorescence at Hurlet, near Paisley, along with natural alum; and sometimes effloresces on old walls.

Uses.—When purified, it is used as a purgative medicine; and it is valued by chemists on account of the magnesia which can be obtained from it.

Genus VI. VITRIOL.

One and three axes. Cleavage rhomboidal, pyramidal, and prismatic. Taste astringent. H. =
Sp. gr. = 1.9—2.2.

1. Rhomboidal Vitriol, or Green Vitriol, *Jameson*—Rhomboedrisches Vitriol Salz, *Mohs.* Eisen Vitriol, *Werner.*

Rhomboid = 81°.23′. Cleavage same, or = *r*. H = 2. Sp. gr. = 1 9, 2.0.

Description.—Colours emerald, apple, and verdigris green, and sometimes grass-green: on exposure to the weather, it becomes straw-yellow, cream-yellow, ochre-yellow, and yellowish-brown. Occurs pulverulent, massive, disseminated, stalactitic, tuberose, botryoidal, reniform, in fibrous distinct concretions, and crystallized. Shining, both externally and internally, and the lustre is vitreous, with exception of the fibrous varieties, which are pearly. Fracture flat conchoidal. Alternates from semi-transparent to opaque. Refracts double.

Chemical Character.—Before the blow-pipe, on charcoal, it becomes magnetic, and colours glass of borax green.

Constituent Parts.—	Oxide of iron	25 7
	Sulphuric acid	28.9
	Water .	45.4—100.0
		Berzelius.

Geognostic and Geographic Situations.—It is always associated with iron pyrites, by the decomposition of which it is formed. Occurs in several coal mines in this country, and in many iron and coal mines on the continent of Europe, and also in America and Asia.

Uses.—It is employed to dye linen yellow, and wool and silk black; in the preparation of ink; of Berlin-blue; for the precipitation of gold from its solution; and sulphuric acid can be obtained from it by distillation. The residue of the latter process (colcothar of iron) is used as a red paint, and, when washed, for polishing steel.

2. Prismatic vitriol, or blue vitriol, *Jameson.* Prismatisches Vitriol-Salz, *Mohs.* Kupfervitriol, *Werner.*

Prism = 124° 2′. Cleavage the same. Hardness = 2.5. Sp. gravity = 2.1, 2.2.

External Characters.—Common colour dark sky-blue, which sometimes approaches to verdigris-green. By exposure to the air it becomes yellow. It occurs massive, disseminated, stalactitic, dentiform, and crystallized. Externally and internally it is shining and vitreous. The fracture is conchoidal. The fragments are rather sharp-edged. It is translucent.

Chemical Characters.—When a portion of it is dissolved in water, and spread on the surface of iron, it immediately covers it with a film of copper.

Constituent Parts.—	Oxide of copper	32.13
	Sulphuric acid	31.57
	Water .	36.30—100.00
		Berzelius.

Geognostic and Geographic Situations.—It occurs, along with copper pyrites, in Pary's mine in Anglesea; and also in the copper-mines in the county of Wicklow in Ireland.

Uses.—It is used in cotton and linen printing; and the oxide separated from it is used by painters.

3. Pyramidal vitriol, or white vitriol, *Jameson.* Pyramid = 120° 90′. Cleavage unknown. Hardness =
Sp. gravity = 2.

External Characters.—Colours greyish, yellowish reddish, and greenish-white. It occurs massive, stalactitic, reniform, botryoidal, in crusts; also in radiated, fibrous, and granular distinct concretions; and crystallized. It is shining, translucent, brittle, and easily frangible.

Chemical Characters.—It intumesces before the blowpipe, but does not phosphoresce; it dissolves in 2.285 parts of boiling water.

		From Rammelberg.	Ditto.
Constit. Parts—	Oxide of Zinc	27.5	21.739
	Oxide of manganese	0 5	6.522
	Sulphuric acid	22.0 }	71.739
	Water .	56.0 }	
		100.0	100

Klaproth, Beit. b. v. s. 196. *Herz.* Archiv. b. iii. s. 537.

Geognostic and Geographic Situations.—It occurs in repositories that contain blende, and appears to be formed by the decomposition of that mineral. It occurs at Holywell in Flintshire; and it is said also in Cornwall.

Uses.—It is used as a medicine; is employed in great quantities by varnishers to make oil drying; and a fine white colour named *Zinc-white*, which is more durable than white-lead, is prepared from it. To prepare this colour, the salt is dissolved in water, and the white oxide, which is the zinc-white, is precipitated from it by means of potash or chalk.

*Red vitriol, or sulphate of cobalt, *Jameson*.—Kobaltvitriol, *Werner*

External Characters.—Colour flesh-red, inclining to rose-red. Occurs coralloidal, stalactitic, in crusts; also in granular distinct concretions. Surface rough, and longitudinally furrowed. Dull, and seldom shining on the surfaces of the distinct concretions, and the lustre is pearly. Fracture earthy. Fragments blunt-edged. Opaque. Affords a yellowish-white streak. Easily friable, and brittle. Taste styptic.

Chemical Characters.—Its solution affords, with carbonate of potash, a pale-bluish precipitate, which tinges borax of a pure blue colour.

Constituent Parts.—Oxide of cobalt	38 71	
Sulphuric acid	19 74	
Water .	41 55	—100.00

Kopfe, in Journal fur di Chemie. Physik et Mineralogie. b. vi. Heft 1. 1808, s. 157.

Geognostic and Geographic Situations.—It occurs in mining-heaps in Biber, along with lamellar heavy-spar, earthy cobalt, and grey cobalt; and it has been also found in the Leogang at Salzburg.

Genus VII. SAL AMMONIAC.

Many axes. Cleavage tessular. Taste sharp and urinous. Hardness=1.5—2. sp. gravity, 1.5.—1.6.

1. Octahedral Sal Ammoniac, *Jameson*.—Octaedrisches Salmiac Salz, *Mohs*. Natürlicher Salmiack, *Werner*.

Tessular. Cleavage octahedral.

This species is divided into two subspecies, viz. Volcanic sal ammoniac, and conchoidal sal ammoniac.

First Subspecies.

Volcanic Sal Ammoniac, *Jameson*.—Vulcanischer Salmiak. *Karsten*.

External Characters.—Colours yellowish and greyish-white; pearl-grey and smoke-grey; wine-yellow; sometimes apple-green, sulphur-yellow, and brownish-black. Occurs in efflorescences, crusts, stalactitic, small botryoidal, tuberose, corroded, also in granular concretions, and caystallized figures. Crystals small and very small; and lateral planes usually smooth. Externally dull or glistening; internally shining and vitreous. Alternates from transparent and opaque. Slightly ductile and elastic.

Chemical Characters.—When moistened, and rubbed with quicklime, it gives out a pungent ammoniacal odour.

	Sal Ammoniac of Vesuvius.
Constituent Parts.—Muriate of ammonia,	99 5
Muriate of soda	0.5—100.0

Klaproth, Beit. b. iii. s. 91.

Geognostic Situation.—As its name implies, it is a volcanic production, occurring in the fissures, or on the surface of volcanic, or pseudo-volcanic rocks.

Geographic Situation.—*Europe*.—It occurs in the vicinity of burning beds of coal, both in Scotland and England. It is found in the island of Iceland. On the continent it is met with at Solfatara, Vesuvius, Ætna, the Lapari Islands, and Tuscany.

Asia.—Thibet, Persia, and the Isle of Bourbon.

America.—In volcanic districts both in North and South America.

Second Subspecies.

Conchoidal Sal Ammoniac, *Jameson*.—Muschlicher Salmiak, *Karsten*.

External Characters.—Colour greyish-white. Occurs in angular pieces. Surface is uneven. Externally glimmering; internally shining and vitreous. Fracture nearly perfect conchoidal. Fragments indeterminate angular. Semi-transparent or transparent. Malleable. Soft. Light. Taste pungent and urinous.

Constituent Parts.—Muriate of ammonia	97.50
Sulphate of ammonia	2.50—100.

Klaproth, Beit. b. iii. s. 94.

Geognotsic and Geographic Situations.—This mineral is said to occur, along with sulphur, in rocks of indurated clay or clay-slate, in the country of Bucharia.

Uses.—This salt is used for a variety of purposes. Great quantities of artificial sal ammoniac are annually exported from this country to Russia, where it appears to be used by dyers. It is employed by copper-smiths, to prevent the oxidation of the surface of the metals they are covering with tin. It renders many metallic oxides volatile, and is frequently used to separate metals from each other.

* Mascagnine, or Sulphate of Ammonia.—Mascagnin, *Karsten*.

External Characters.—Colours yellowish-grey, lemon-yellow. Occurs in meally crusts, or stalactitic. Internally dull or glistening. Fracture uneven or earthy. Semi-transparent or opaque. Taste sharp and bitter.

Chemical Characters.—It is easily soluble in water; partly volatilised by heat; and becomes moist on exposure to the air.

Constituent Parts.—It is a compound of ammonia, sulphuric acid, and water.

Geognostic and Geographic Situations.—It occurs among the lavas of Ætna and Vesuvius; in the Solfatara by Puzzæolo; in the lagunes, near Siena in Tuscany; and on the bottom of a hot spring in Dauphiny.

Genus VIII. ROCK-SALT.

Steinsalz, *Werner* and *Mohs*.

Many axes. Cleavage tessular. Taste saline. Hardness=2.0—2.5. Sp. gravity=2.1, 2.2.

1. Hexahedral Rock-Salt, *Jameson*.—Hexaedrisches Steinsalz. *Mohs*.

Tessular. Cleavage hexahedral.

This species is divided into two subspecies, viz. rock-salt and lake-salt.

First Subspecies.

Rock-Salt. Steinsalz, *Werner*.

This subspecies is divided into two kinds, viz. Foliated rock-salt and fibrous rock-salt.

First Kind.

Foliated Rock-Salt, *Jameson*. Blättriches Steinsalz, *Werner*.

External Characters.—Its most common colours are white and grey. Of white, it occurs greyish, yellowish, and milk-white; but it seldom approaches to snow-white. Of grey, ash, smoke, and pearl-grey. From pearl-grey it passes, though rarely, into flesh, blood, and brick red. Still seldomer do we observe the white varieties marked with Berlin, azure, violet, or lavender blue spots or patches. It is said also to occur ochre-yellow, wine-yellow, and emerald-green. It occurs massive, disseminated, in minute veins, in crusts, plates, and stalactitic ; also in distinct concretions, which are large, coarse, small, and fine angulo-granular, and these sometimes incline to prismatic.* On the fresh fracture shining or resplendent, lustre resinous. Fracture conchoidal. Fragments cubic. In general it is strongly translucent, sometimes semi-transparent and transparent. Feels rather greasy. Rather brittle, and easily frangible.

Second Kind.

Fibrous Rock-Salt, *Jameson.* Fasriges Steinsalz, *Werner.*

External Characters.—Colours greyish, yellowish, and snow white ; from these it passes into ash and smoke grey ; more rarely it is marked with stripes of flesh red, violet, sky, and Berlin blue. Occurs massive and dentiform ; also in distinct concretions, which are coarse and fine, and straight and curved fibrous. Internally it is shining and glistening, and the lustre is resinous. The fragments are splintery. Strongly translucent, verging on semi-transparent. In other characters it resembles the preceding kind.

Chemical Characters.—It decrepitates briskly when exposed to the action of the blow-pipe, or when laid on burning coals.

		Cheshire Rock-Salt.
Constituent Parts.—	Muriate of soda	$983\frac{1}{4}$
	Sulphate of lime	$6\frac{1}{2}$
	Muriate of magnesia	$0\frac{3}{16}$
	Muriate of lime	$0\frac{1}{16}$
	Insoluble matter	10—1000.0

Henry, *Philosophical Transactions* for 1810, pt. i. p. 97.

Geognostic Situation.—It occurs in transition rocks in Switzerland, and in secondary rocks in Germany, England, and South America.

Geographic Situation.—*Europe.*—The principal deposite of salt in this island is that in Cheshire, where there are several beds that vary in thickness from four feet to upwards of one hundred and thirty feet, and alternate with clay and marl, which contain compact, foliated, granular, and radiated gypsum. Rock-salt also occurs at Droitwich in Worcestershire ; and in Germany, France, Hungary, and Spain.

Africa.—Besides the great beds of this mineral found in Europe, it is also very extensively distributed in other quarters of the globe. In the northern part of Africa, on both sides of the Atlas Mountains, vast quantities of rock-salt occur. In the valley of Egarement there are beds of rock-salt resting on gypsum. Mr. Horneman, on his journey from Cairo to Ummosogeir, discovered a plain on the summit of the chain of limestone mountains that bound the desert of Lybia to the north, consisting of a mass of rock-salt, spread over so large a tract of surface, that in one direction no eye could reach its termination, and its width he computed at several miles. To the south-east of Abyssinia, there is a plain of rock-salt four days journey across, whence all that country is supplied.† At Tegazza, and in several other places in Sahara, very large beds of pure rock-salt occur under strata of different kinds of solid rock ; and beds of salt appear at Darfur, and in the country of Congo.

Asia.—There is a considerable mine of rock-salt twenty versts from Jena-Tayerska, in the desert between the Volga and the Uralian Mountains; another named Iletzki near Astracan ; and there are several others in Siberia.‡ Salt mines are worked in that part of China which borders on Tartary. At Teflis, Tauris, and other places in Persia, there are great masses of rock-salt; and we are informed, that in the desert of Caramania, and also in Arabia, rock-salt is so abundant, and the atmosphere is so dry, that the inhabitants use it for building houses. The Island of Ormuz, situated in the mouth of the Persian Gulf, is principally composed of rock-salt. Rock-salt is one of the mineral productions of the valley of Cashmere ; and in the province of Lahore, in India, there is a hill of rock-salt equal to that of Cordona ; the salt of this hill is cut into dishes, plates, and stands for lamps.

America.—Rock-salt is found in vast quantity on the elevated deserts of Peru, where it is very hard, and has usually a violet colour ; also in the Cordilleras of New Granada, at the height of 2000 toises. It occurs in considerable quantity in Upper Louisiana ; and great masses of it have been found at the junction of the stream of Atha-pus-caou with the Atha-pus-caou lake ; and in California.

New Holland.—According to Governor Hunter, it is found in considerable quantity on the east coast of New Holland.

Uses.—Its uses are very various and important. We make use of it daily as a seasoning for our food : vast quantities are employed for the preservation of animal flesh, butter, &c. ; it is also used in the manufacture of earthen ware, soap-making, and in many metallurgic operations. It affords muriatic acid and soda by certain chemical processes. It is sometimes employed in its crude state, but is more commonly purified.

Second Subspecies.

Lake-Salt, *Jameson.*—Seesalz, *Werner.*

External Characters.—Colour greyish-white. Occurs in coarse and small roundish grains. Internally shining or glistening, and the lustre resinous. Fracture is imperfect foliated. In other characters it agrees with the other subspecies.

Geognostic and Geographic Situations.—It is found on the bottoms and sides of salt-lakes. In Europe, Asia, and also in Africa and America.

CLASS II.

Tasteless. Specific gravity above 1.8.

Order I.—HALOIDE.

No metallic lustre. Streak not changed in the colour.

Cleavage.—If in the direction of a four-sided prism, the hardness is equal to four and less : if axifrangible and prismatoidal, the hardness and specific gravity are below 3. Hardness ranges from 1.5 to 5. If the hardness is less than 2.5, the specific gravity will be 2.4 and

* Some authors describe rock-salt in globular and columnar concretions.

† Bruce mentions, that in some parts of Abyssinia, cubic pieces of rock-salt pass as current coin.

‡ Pallas speaks of rock-salt in the neighbourhood of the river Jaik, which is sometimes so hard as to snap the pick-axes made use of in quarrying it.

less. Specific gravity ranges from 2.2 to 3.2. If less than 2.4, the hardness will be 2.4, and less.

Genius. I.—GYPSUM.

Three axes . Cleavage prismatic. Hardness =1.5—3.5. Sp. gr. =2.2—3.0.

1. Axifrangible Gypsum, *Jameson*.—Axentheilendes Gyps-Haloide, *Mohs*.

Prism =113° 8′. Cleavage perpendicular to the axis, or axifrangible. Hardness =1.5—2.0. Sp. gr. =2.2 2.4.

This species contains six subspecies, viz. Sparry Gypsum or Selenite, Foliated Granular Gypsum, Compact Gypsum, Fibrous Gypsum, Scaly Foliated Gypsum, and Earthy Gypsum. *Montmartrite.

First Subspecies.

Sparry Gypsum or Selenite, *Jameson*.—Fraueneis, *Werner*.

External Characters.—Colours smoke-grey, greyish-white, snow-white, greenish-white, and yellowish-white, and also wax-yellow, pale ochre-yellow, and yellowish-brown. Sometimes dark-brown, owing to intermixed stinkstone. Some varieties display iridescent colours. Occurs massive, coarsely disseminated, also in distinct concretions, which are large and coarse granular, and sometimes inclining to thick lamellar; and crystallized. The following are some of the secondary figures:

1. Six-sided prism. 2. Lens. 3. Twin-crystals. These are either formed by two lenses, which are attached by their faces, or by two six-sided prisms pushed into each other in the direction of their breadth, in such a manner, that the united summits at one extremity form a re-entering angle, but at the other a salient angle, or four-planed acumination. When two such twin-crystals are pushed into each other in the direction of their length, a 4. Quadruple crystal is formed.

Lateral planes of the prism sometimes smooth, sometimes longitudinally streaked, and shining; the convex terminal faces, and lens, are rough and dull. Internally, lustre splendent and pearly. Cleavage threefold; the most distinct cleavage perpendicular to the axis of the prism; the other two parallel with the lateral planes of the primitive prism. Cleavages generally straight, and sometimes curved. Fragments rhomboidal, in which two of the sides are smooth and splendent, and four are streaked and shining. Alternates from semi-transparent to transparent, and in the latter case is observed to refract double. Sectile. Very easily frangible. In thin pieces flexible, but not elastic.

Chemial Characters.—Exfoliates before the blowpipe, and, if the flame is directed towards the edge of the folia, it melts into a white enamel, which, after a time, falls into a white powder.

Constituent Parts.—Lime,	. .	33.9
	Sulphuric Acid	43.9
	Water . .	21.0
	Loss, . .	2.1—100.0

Bucholz, in Gehlen's Journ. b. v. s. 158.

Geognostic Situation.—Occurs principally in the secondary or flœtz gypsum formation, in thin layers: less frequently in rock-salt; more rarely as a constituent part of metalliferous veins; but in considerable quantity in that deposite known in the south of England under the name of Blue or London Clay. Crystals of this substance are daily forming in gypsum hills, in old mines, and in mining heaps.

Geographic Situation.—It is not unfrequent in the blue clay in the south of England, as at Shotover Hill, near Oxford, and occurs in the secondary gypsum around Paris.

Uses.—At a very early period, before the discovery of glass, selenite was used for windows; and we are told, that, in the time of Seneca, it was imported into Rome from Spain, Cyprus, Cappadocia, and even from Africa. It is used for the finest kind of stucco, and the most delicate pastil colours. When burnt, and perfectly dry, it is used for cleansing and polishing precious stones, work in gold and silver, and also pearls.

Second Subspecies.

Foliated Granular Gypsum, *Jameson*.—Blættrigger Gyps, *Werner*.

External Characters.—Most common colours white, grey, and red; seldomer yellow, brown, and black. Occurs massive, also in granular and prismatic distinct concretions. Sometimes crystallized in small conical lenses, in which the surface is rough. Lustre passes from shining through glistening to glimmering, and is pearly. Has the same cleavage as selenite. Fragments very blunt edged. Translucent. Sectile, and very easily frangible.

Constituent Parts.—Lime,	.	32
	Sulphuric Acid,	30
	Water .	38—98 *Kirwan*.

Geognostic Situation.—It occurs in beds in primitive rocks: in a similar repository in transition clay-slate; but most abundantly in beds in rocks of the secondary or flœtz class.

Geographic Situation.—It occurs in Cheshire and Derbyshire; at the Segeberg, near Kiel; and at Lunebürg, where it contains crystals of boracite, and sometimes of quartz; and in many other parts of Europe.

Uses.—The foliated and compact subspecies of gypsum, when pure, and capable of receiving a good polish, are by artists named simply *Alabaster*, or, to distinguish them from calc-sinter, or what is called calcareous alabaster, *Gypseous Alabaster*. The finest white varieties of granular gypsum are selected by artists for statues and busts: the variegated kinds are cut into pillars, and various ornaments, for the interior of halls and houses; and the most beautiful variegated sorts are cut into vases, columns, plates, and other kinds of table furniture. Those varieties that contain imbedded portions of selenite, when cut across, exhibit a beautiful iridescent appearance, and are named *Gypseous Opal*. In Derbyshire, and also in Italy, the very fine granular varieties are cut into large vases, columns, watch-cases, plates, and other similar articles. Both subspecies are used in agriculture. Much difference of opinion has prevailed among agriculturists with respect to the uses of gypsum. It is said to have been very advantageously employed in America, and also in the county of Kent; but it has failed in most of the other counties of England, though tried in various ways, and for different crops. When peat-ashes contain a considerable portion of gypsum, they may be advantageously employed as a top-dressing for cultivated grasses, on such soils as contain little or no sulphate of lime. The pure white varieties of granular gypsum are used as ingredients in the composition of earthen-ware and porcelain; and the glaze or enamel with which porcelain is covered, has the purest gypsum, or even selenite, as one of its ingredients. Its most important use is in the preparation of *stucco.*

Third Subspecies.

Compact Gypsum, *Jameson.*—Dichter Gyps, *Werner.*

External Characters.—Colours white, grey, blue, red, and sometimes honey-yellow. Occurs massive. Generally dull, seldom feebly glimmering. Fracture fine splintery, passing on the one side into even, on the other into fine-grained uneven. Fragments indeterminate angular, and blunt-edged. Translucent on the edges.

Chemical Characters.—All the different varieties of gypsum, when exposed to heat, are deprived of their water of crystallization, become opaque, fall into a powder, which, when mixed with water, speedily hardens on exposure to the air. They are difficultly fusible before the blowpipe, without addition, and melt into a white enamel: when heated with charcoal, they are converted into sulphuret of lime.

Constituent Parts.—Lime,	.	34
Sulphuric acid,		48
Water,	.	18—100 *Gerhard.*

Geognostic Situation.—Occurs in beds, along with granular gypsum, selenite, and stinkstone, in the flœtz or secondary class of rocks.

Geographic Situation.—Occurs in the Campsie Hills; Derbyshire; Ferrybridge in Yorkshire; and Nottinghamshire.

Fourth Subspecies.

Fibrous Gypsum, *Jameson.*—Fasriger Gyps, *Werner.*

External Characters.—Principal colours white, grey, red, and yellow. Occurs massive, and dentiform; also in fibrous distinct concretions, which are parallel, generally straight, and sometimes curved. Lustre passes from glistening, through shining to splendent, and is pearly. Fragments are long splintery. Translucent.

Constituent parts.—Lime,	. .	33.00
Sulphuric Acid,		44.13
Water,	. .	21.00—98.13

Bucholz, N. Allg. Journ. d. Chem. b. v. H. ii. s. 160.

Geognostic Situation.—It occurs along with the other subspecies of this species.

Geographic Situation.—It occurs in red sandstone, near Moffat; in red clay, on the banks of the Whitadder in Berwickshire; in Dunbartonshire; also in Cumberland, Yorkshire, Cheshire, Worcestershire, Derbyshire, Somersetshire, and Devonshire.

Uses.—When cut *en cabochon*, and polished, it reflects a light not unlike that of the cat's-eye, and is sometimes sold as that stone. It is also cut into necklaces, ear pendents, and crosses; and in this form it is also sold for a harder mineral, the Fibrous Limestone, or even imposed on the ignorant for that variety of felspar named Moonstone.

Fifth Subspecies.

Scaly Foliated Gypsum, *Jameson.*—Schaumgyps, *Werner.*

External Characters.—Colours yellowish-white and snow-white. Occurs massive and disseminated; also in distinct concretions, which are small and scaly granular. Internally glistening and pearly. Fracture small scaly foliated. Fragments indeterminate angular, and blunt-edged. Opaque, or translucent on the edges. Sectile, and easily frangible.

Geognostic and Geographic Situations.—It occurs with selenite and compact gypsum at Montmartre, near Paris, in that formation of gypsum named by Werner the third or yellow flœtz gypsum formation

Sixth Subspecies.

Earthy Gypsum, *Jameson.*—Gyps-erde, *Werner.*

External Characters.—Colour yellowish-white, which passes into yellowish-grey, and sometimes inclines to snow-white. Composed of fine scaly or dusty particles, which are more or less cohering. Feebly glimmering. Feels meagre, and rather fine. Soils slightly. Light.

Geognostic Situation.—It is found immediately under the soil, in beds several feet thick, resting on gypsum, and also in nests or cotemporaneous masses imbedded in it.

Geographic Situation.—It is found in Saxony, Switzerland, Salzburg, and Norway.

*Montmartrite.—Chaux sulphatée calcarifere, *Lucas & Huay.* Gypsum of Montmartre.

External Characters.—Colour yellowish. Occurs massive, but never crystallized. Soft. Effervesces with nitric acid.

The Montmartrite is composed of gypsum and carbonate of lime. This carbonate is converted into quicklime in the furnace, and thus a kind of mortar is formed: it is on this account, that the *plaster* made of this mineral may be used in work exposed to the weather; while that of pure gypsum, on exposure, soon yields to the action of rain. The montmartrite contains about—

Sulphate of Lime,	83
Carbonate of Lime,	17—100

II. Prismatic Gypsum, or Anhydrite, *Jameson.*—Prismatisches Gyps-Haloide, *Mohs.*—Muriacit, *Werner.*

Prism=100° 8′. Three cleavages, perpendicular to each other. Hardness=3.0—3.5. Specific gravity=2.7—3.0.

It is divided into five subspecies, viz. Sparry Anhydrite, Scaly Anhydrite, Fibrous Anhydrite, Conchoidal Anhydrite, Compact Anhydrite. *Vulpinite. *Glauberite.

First Subspecies.

Sparry Anhydrite, or Cube-Spar, *Jameson.*—Wurfelspath, *Werner.*

External Characters.—Chief colour white, which passes on the one side into blue, and on the other into red. Occurs massive; also in distinct concretions, which are thin and straight lamellar, collected into others which are large granular. Sometimes crystallized in the following figures.

1. Rectangular four-sided prism: it is sometimes so low as to appear as a four-sided table. 2. Broad six-sided prism. 3. Eight-sided prism. 4. Broad rectangular four-sided prism, acuminated on the extremities with four planes, which are set on the lateral edges, and the apex of the acumination deeply truncated.

Externally shining or splendent, and pearly: internally splendent and pearly. Fragments cubical. Fracture conchoidal. Alternates from transparent to strongly translucent, and refracts double. Brittle, and very easily frangible.

Chemical Characters.—When exposed to the blowpipe, it does not exfoliate, and melt like gypsum, but becomes glazed over with a white friable enamel.

	From Bern.	From Tyrol.
Constit. Parts. Lime	40	41 75
Sulphuric Acid,	60	55.00
Muriate of Soda,		1.00
	100	97.75
	Hauy, Traité, t. iv. p. 349.	*Klaproth*, Beit. b. iv. s. 235.

Geognostic and Geographic Situations.—It is sometimes met with in the gypsum of Nottinghamshire. In the salt-mines of Hall in the Tyrol, and in other countries.

Second Subspecies.

Scaly Anhydrite, *Jameson.*—Anhydrite, *Werner.*

External Characters.—Colours white, smalt-blue, and rarely grey. Occurs massive, and in small granular concretions. Lustre splendent and pearly. Cleavage imperfect and curved. Fragments not particularly blunt-edged. Translucent on the edges. Easily frangible.

Constituent Parts.—Lime, 41.75
Sulphuric Acid, 55.00
Muriate of Soda, 1.00—97.75
Klaproth, Beit. b. iv. s. 235.

Geognostic and Geographic Situations.—It is found in the salt-mines of Hall in the Tyrol, 5088 feet above the level of the sea.

Third Subspecies.

Fibrous Anhydrite, *Jameson.*—Fasriger Muriacit, *Werner.*

External Characters.—Colours red; also blue and grey. Occurs massive, and in coarse fibrous concretions, which are straight or curved, and sometimes stellular. Internally glimmering and glistening, and pearly. Fragments long splintery. Translucent on the edges, or feebly translucent. Rather easily frangible.

Geographic Situation.—It is found in the salt-mines of Berchtesgaden, and at Ischel in Upper Austria, at Hall in the Tyrol, Salz on the Neckar, Carinthia, and Tiede near Brunswick.

Uses.—The blue varieties are sometimes cut and polished for ornamental purposes.

Fourth Subspecies.

Convoluted Anhydrite, *Jameson.*—Gekröstein, *Werner.*

External Characters.—Colour dark milk-white. Occurs massive; also in distinct concretions, which are thick lamellar, and intestinally convoluted or contorted, and these are again composed of others which are thin prismatic. Internally glistening or glimmering, and the lustre pearly. Fracture small and fine splintery. Fragments indeterminate angular, and rather sharp-edged. Translucent on the edges, or translucent.

Constituent Parts.—Lime, 42.00
Sulphuric Acid, 56.50
Muriate of Soda, 0.25—98.75
Klaproth, Beit. b. iv. s. 233.

Geognostic and Geographic Situations.—It occurs in the salt-mines of Bochnia and at Wieliczka in Poland.

Observations.—It was first described as a variety of compact heavy spar, and is by many named *Pierre de Tripes*, from its convoluted concretions.

Fifth Subspecies.

Compact Anhydrite, *Jameson.*—Dichter Muriacit, *Werner.*

External Characters.—Colours bluish-white, and tile-red. Sometimes with spotted delineations. Occurs massive; also in granular distinct concretions. Feebly glimmering, or dull. Fracture small splintery, passing into even and flat conchoidal. Fragments more or less sharp-edged. Alternates from translucent to translucent on the edges.

Constituent Parts.—Lime, 41.48
Sulphuric Acid, 56 28
Water, 0.75—100.00
Rose, in Karsten's Tabellen.

Geognostic and Geographic Situations.—It occurs in beds in the salt mines of Austria and Salzburg; and also in secondary gypsum, on the eastern foot of the Hartz mountains.

*Vulpinite.

External Characters.—Colour greyish-white, and veined with bluish-grey. Occurs massive. Internally splendent. Fracture foliated. Fragments rhomboidal. Occurs in granular distinct concretions. Translucent on the edges. Brittle. Easily frangible.

Chemical Characters.—It melts easily before the blowpipe into a white opaque enamel; and becomes feebly phosphorescent when thrown on glowing coals.

Constituent Parts.—Sulphate of Lime, 92.0
Silica, 8.0—100.0
Vauquelin. in Bulletin des Sciences de la Société Philomatique, N. 9.; Journal de Physique, t. xlvii. p. 101.; Journal des Mines, N. xxxiv.

Geognostic and Geographic Situations.—It occurs along with granular foliated limestone, and is sometimes associated with quartz, and occasionally with sulphur. It is found at Vulpino in Italy.

Uses.—1. It takes a very fine polish, and is employed by the statuaries of Bergamo and Milan for making slabs, chimney-pieces, &c. It is known to artists by the name *Marmo bardiglio di Bergamo*. 2. It was first particularly noticed by Fleuriau.

*Glauberite.—Glauberite, *Brongniart.*

External Characters.—Colours greyish-white, and wine-yellow. Occurs crystallized, in very low oblique four-sided prisms, the lateral edges of which are 104° 28′ and 75° 32′, and in which the terminal planes are set on obliquely. Crystals occur singly, or in groups. Lateral planes transversely streaked; the terminal planes smooth. Shining. The fracture parallel with the terminal planes and edges is foliated; in other directions it is conchoidal. Softer than calcareous spar. Transparent. Brittle. Specific gravity 2.700.

Chemical Characters.—It decrepitates before the blowpipe, and melts into a white enamel. In water it becomes opaque, and is partly soluble.

Constituent Parts.—Dry Sulphate of Lime, 49.0
Dry Sulphate of Soda, 51.0
100.0
Brongniart. J. des Mines, t. xxiii. p. 17.

Geognostic and Geographic Situations.—It is found imbedded in rock-salt at Villaruba, near Ocana in New Castile, in Spain.

Observations.—It was brought from Spain to Paris by M. Dumeril, and first analyzed and described by Brongniart.

Genus II.—CRYOLITE.

Eis-Haloide, *Mohs.*

One axis. Cleavage pyramidal. One perpendicular cleavage, and other two less perfect. Hardness =2.5—3.0. Specific gravity =2.9—3.

1. Pyramidal Cryolite, *Jameson.*—Pyramidales Eis-Haloide, *Mohs.*

Pyramid unknown. The most perfect cleavage is parallel with the terminal planes of a rectangular four-sided prism; another less distinct, parallel with the diagonals of a rectangular four-sided prism; and a third, still less perfect, parallel with the planes of the pyramid.

External Characters.—Colours pale greyish-white, snow-white, yellowish-brown, and yellowish-red. Occurs massive, disseminated, and in straight and thick lamellar distinct concretions. It is shining, inclining to glistening, and the lustre is vitreous, inclining to pearly. Fracture uneven. Fragments cubical or tabular. Translucent. Brittle, and easily frangible.

Chemical Characters.—It becomes more translucent in water, but does not dissolve in it. It melts before it reaches a red heat, and when simply exposed to the flame of a candle. Before the blowpipe, it at first runs into a very liquid fusion, then hardens, and at length assumes the appearance of a slag.

Constit. Parts.—		
Alumina,	24.0	21.0
Soda,	36.0	32.0
Fluoric Acid, and Water,	40.0	47.0
	100.0	100.0
	Klaproth, Beit. b. iii. s. 214	*Vauquelin*, Hauy, Traié. t. ii. p. 400.

Geognostic and Geographic Situations.—This curious and rare mineral has been hitherto found only in West Greenland, and but in one place of that dreary and remote region, viz. the Fiord or arm of the sea named Arksut, situated about thirty leagues from the colony of Juliana Hope, where it occurs in two thin layers in gneiss.

Genus III. ALUM-STONE.

Thon Haloide, *Mohs.* Alaunstein, *Werner.*

One Axis. Cleavage rhomboidal. Hardness =5.0. Sp. gr. =2.4.—2.6.

1. Rhomboidal Alumstone, *Jameson.*—Rhombœdrishes Thon Haloide, *Mohs.*

Rhomboid unknown. The most distinct cleavage parallel with the sides of a rhomboid; another, less distinct, parallel with the terminal plane of a six-sided prism.

External Characters.—Colours white, pale flesh-red, and more rarely pearl-grey and bluish-grey. Sometimes several of these colours occur together in spotted, striped, and veined delineations. Occurs massive, sometimes porous, or nearly vesicular, with the walls lined with small crystals. Internally it is dull, or feebly glimmering. Fracture coarse, small grained uneven, which passes into splintery, earthy, and flat conchoidal. Fragments indeterminate angular, and rather sharp-edged. Feebly translucent on the edges. Brittle and easily frangible.

Constituent Parts.

		Alumstone from Tolfa.	Hungarian Alumstone.
Alumina,	43.92	19.00	17.50
Silica,	24.00	56.50	62.25
Sulphuric Acid,	25.00	16.50	12.50
Potash,	3.08	4.00	1.00
Water,	4.00	3.00	5.00
		99.00	98 25
	Vauquelin.	*Klaproth*, Beit. b. iv. s. 252	*Klaproth*, Id. s. 256.

Geognostic and Geographic Situations.—It occurs at Tolfa, near Civita Vecchia, in nests, kidneys, and small veins, in a flœtz or secondary rock. The Hungarian varieties are found in beds at Bergszaz and Nagy-Begany, in the country of Beregher, in Upper Hungary.

Uses.—Alum is obtained from this mineral, by repeatedly roasting it, then lixiviating it, and crystallizing the solution thus obtained.

Genus IV. FLUOR.

Many axes. Cleavage octahedral. Hardness = 4.0. Sp. gr. = 3.0, 3.1.

This genus contains but one species, viz. Octahedral Fluor.

1. Octahedral Fluor, *Jameson.*—Flus, *Werner.* Octaedrisches Flus Haloide, *Mohs.*

Tessular. Cleavage octahedral. Hardness = 4.0.

It is divided into three subspecies, Compact Fluor, Foliated Fluor, and Earthy Fluor.

First Subspecies.

Compact Fluor, *Jameson.*—Dichter Flus, *Werner.*

External Characters.—Colours greenish-grey, greenish-white, brownish-red, mountain-grey, and greenish-black. Occurs massive. Externally and internally dull, or feebly glimmering. Fracture even, passes on one side into small splintery, on the other into flat conchoidal. Fragments rather sharp-edged. More or less translucent. Brittle, and easily frangible.

Chemical Characters.—The chemical characters are those of the following subspecies.

Geognostic and Geographic Situations.—It is found in veins, associated with fluor-spar, at Stolberg, in the Hartz.

Second Subspecies.

Foliated Fluor, *Jameson.*—Flus-Spath, *Werner.*

External Characters.—Most common colours white, yellow, green and blue, seldomer red, grey, brown, and least frequently black. Colours of all degrees of intensity, and sometimes pieces occur spotted or striped. Green cubes occur with blue angles, &c. Some colours, as sky-blue, fade by keeping, particularly in warm places. Occurs massive, disseminated, also in distinct concretions, which are large, coarse, small, and fine granular, sometimes straight prismatic, which are traversed by others that are thick and fortification-wise curved lamellar. Striped colour delineation in the direction of these concretions. It occurs crystallized, in the following figures:

1. Cube. 2. Cube, truncated on all the edges. 3. The rhomboidal or garnet dodecahedron. 4. Cube, with truncated angles. 5. Octahedron, or regular double four-sided pyramid. 6. Cube, with bevelled edges.

7. Cube, in which all the angles are acuminated with three planes, which are set on the lateral planes. 8. Cube, in which all the angles are acuminated with six planes, which are set on the lateral planes.

Cubes vary from very large to very small; the other crystals are only small and middle sized. Crystals generally placed on one another, and form druses; but are seldom single. Surface smooth and splendent, or drusy and rough, as in the rhomboidal dodecahedron, and some octahedrons. Internally the lustre is specular-splendent, or shining and vitreous. Fragments octahedral or tetrahedral. Alternates from translucent to transparent, and refracts single. Is brittle, and easily frangible.

Chemical Characters.—Before the blowpipe it generally decrepitates, gradually loses its colour and transparency, and melts, without addition, into a greyish-white glass. When two fragments are rubbed against each other, they become luminous in the dark. When gently heated, or laid on glowing coal, it phosphoresces, (particularly the sky-blue, violet-blue, and green varieties,) partly with a blue, partly with a green light. When brought to a red-heat, it is deprived of its phosphorescent property. The violet-blue variety from Nertschinsky, named *Chlorophane*, when placed on glowing coals, does not decrepitate, but soon throws out a beautiful verdigris-green and apple-green light, which gradually disappears as the mineral cools, but may be again excited, if it is heated; and this may be repeated a dozen of times, provided the heat is not too high. When the chlorophane is exposed to a red-heat, its phosphorescent property is entirely destroyed. Pallas mentions a pale violet blue variety spotted with green, from Catharinenburg, which is so highly phosphorescent, that, when held in the hand for some time, it throws out a pale whitish light; when placed in boiling water, a green light; and exposed to a higher temperature, a bright blue light. When sulphuric acid is added to heated fluor-spar, in the state of powder, a white penetrating vapour (the fluoric acid) is evolved, which has the property of corroding glass.

Constituent Parts.

	Northumberland.	Gersdorf.	Gersdorf.
Lime	67.34	67.75	65.0
Fluoric Acid	32.66	32.25	35.0
	100 00	100.00	100.0
	Thomson, in Wern. Mem. vol. i. p. 11.	*Klaproth*, Beit. b. iv. s. 365.	*Richter*, Uber die Neuren Gegnest. v. Chem. b. iv. s. 25.

Geognostic Situation.—It occurs principally in veins that traverse primitive, transition, and sometimes secondary rocks; also in beds, associated with other minerals; in kidneys in secondary limestone; and in drusy cavities in trap-rocks.

Geographic Situation.—*Europe.* Fluor-spar is a rare mineral in Scotland, having been hitherto found only in four places, viz. near Monaltree in Aberdeenshire, where it is contained in a small vein of galena or lead-glance which traverses granite; in gneiss in Sutherland; in secondary porphyry near the village of Gourock in Renfrewshire; and in the island of Papa Stour, one of the Shetland islands, in small quantity, in a trap-rock. It occurs much more abundantly in England, being found in all the galena veins that traverse the coal formation in Cumberland and Durham; in great quantities, and often associated with galena, in veins or kidneys, in secondary or flœtz limestone, in Derbyshire; and it is the most common vein-stone in the copper, tin, and lead veins that traverse granite, clay-slate, &c. in Cornwall and Devonshire.

Uses.—On account of the variety and beauty of its colours, its transparency, the ease with which it can be worked, and the high polish it receives, it is cut into vases, pyramids, and other ornamental articles. The largest masses, and most beautiful varieties for use, are found in Derbyshire, and it is in that county that all the ornamental articles of fluor-spar are manufactured. It is also used by the metallurgist, as a flux for ores, particularly those of iron and copper; and hence the name *fluor* given to it. The acid it contains has been employed in the way of experiment for engraving upon glass.

Third Subspecies.

Earthy fluor, *Jameson.*—Erdiger Fluss, *Karsten.*

External Characters.—Colours greyish white, and violet-blue, and sometimes so deep as almost to appear black. Occurs generally in crusts, investing some other mineral. Dull. Earthy. Friable, passing into very soft.

Constituent Parts.—It is said to be a compound of Lime and fluoric acid.

Geognostic and Geographic Situations.—It occurs in veins, along with fluor-spar, at Beeralston in Devonshire; in limestone, along with fluor-spar and arragonite, in Cumberland.

Genus V.—APATITE.

One axis. Cleavage rhomboidal. Hardness $=5$ 0. Sp. gravity $=3.1$, 3.2.

1. Rhomboidal apatite, *Jameson.*—Rhomboedrischer Flus Haloide, *Mohs.*—Apatit, *Werner.*

Di-rhomboid $=131°$ 49′, 109° 28′. The most perfect cleavage is parallel with the terminal planes of a six-sided prism; another, less distinct, parallel with the sides of a regular six-sided prism. Hardness $=5.0$.

This species is divided into three subspecies, viz. Foliated Apatite, Conchoidal Apatite, and Lamellar Apatite.

First subspecies.

Foliated apatite, *Jameson.*—Geminer Apatite, *Werner.*

External Characters.—Its most frequent colour is white; from greenish-white it passes into mountain-green, celandine-green, light-green, emerald-green, and olive-green. It occurs also red and blue. Sometimes it is pale wine-yellow, and yellowish-brown. Frequently several of these colours occur in the same piece. It sometimes occurs massive and disseminated, also in distinct concretions, which are large and small angulo-granular, and sometimes thin and straight lamellar; generally crystallized. Its secondary figures are the six-sided prism, and six-sided table, variously modified by truncations, bevelments, and acuminations. The crystals are small, very small, and middle-sized; and occur sometimes single, sometimes many irregularly superimposed on each other. The lateral planes are seldom smooth, generally longitudinally streaked; the truncating and acuminating planes are smooth. Externally it is splendent or shining; internally glistening, and the lustre is resinous. Fracture intermediate between uneven and imperfect conchoidal. Fragments indeterminate angular, and rather sharp-edged. Generally translucent; seldom nearly transparent, when it refracts single. Brittle, and easily frangible.

Physical Characters.—It becomes electric by heating, and also by being rubbed with woollen cloth.

Chemical Characters.—When thrown on glowing coals, it emits a pale grass-green phosphoric light. It dissolves very slowly in the nitric acid, and without effervescence. It gradually loses its colour, when heated before the blowpipe, but its lustre and transparency are heightened. It is infusible without addition.

Constituent Parts.	Lime . . .	55
	Phosphoric Acid, and trace of Manganese	45—100

Klaproth, Bergm. Journ. 1788, b. i. s. 269.

Geognostic Situation.—It occurs in tin-stone veins, and also imbedded in talc.

Geographic Situation.—*Europe.*—It occurs in yellow foliated talc, and, along with fluor-spar, in the mine called Stena-Gwyn, in St. Stephen's, in Cornwall, also at St. Michael's Mount, Godolphin-bal in Breage, also in Cornwall; and in various districts on the continent of Europe.

America.—It occurs in grains or hexahedral prisms in granite, near Baltimore, in Maryland; in granite and gneiss, along with beryl, garnet, and schorl, at Germantown in Pennsylvania; in iron-pyrites at St. Anthony's Nose, in the Hudson in New York; in granite, at Milford hills, near New Haven in Connecticut; and at Topsham in Maine, in granite.

Second Subspecies.

Conchoidal Apatite or Asparagus Stone, *Jameson.*—Muschlicher Apatit, *Hausmann.* Spargelstein, *Werner.*

External Characters.—Colours green and wine-yellow, bordering on orange-yellow. Also sky-blue, greenish and yellow-grey, and clove-brown. Sometimes massive and disseminated, also in distinct concretions, which are large granular; but most frequently crystallized, and in the following figures:

1. Equilateral, longish, six-sided prism, acuminated with six planes, which are set on the lateral planes. 2. The same figure, truncated on the lateral edges of the prism.

Crystals middle-sized, small, and very small; sometimes longitudinally streaked, and sometimes traversed by cross rents. Externally crystals splendent and vitreous: internally shining, and resinous. Fracture small and imperfect conchoidal. Fragments rather blunt-edged. Alternates from transparent to translucent. In other characters agrees with the foliated apatite.

Chemical Characters.—Some varieties of this subspecies do not phosphoresce when exposed to heat.

Constituent Parts.

Apatite from Utö.		From Zillerthal.	
Phosphate of Lime,	92 00	Lime, . .	53.75
Carbonate of Lime,	6.00	Phosphoric Acid,	46 25
Silica, . .	1.00		
Loss in heating, .	0.50		100
Manganese a trace.	——		*Klaproth*, Beit. b. iv. s. 197.
	99 50		
	Klaproth, Beit. b. v. s 181.		

Geognostic and Geographic Situations.—*Europe.*—It occurs, imbedded in gneiss, near Kincardine in Ross-shire; also in beds of magnetic ironstone, along with sphene, calcareous-spar, hornblende, quartz, and augite, at Arendal in Norway.

America.—Imbedded in granite at Baltimore; in gneiss at Germantown; and in mica-slate in West Greenland.

Third Subspecies.

Phosphorite, *Jameson.* Phosphorit, *Werner.*

This Subspecies is divided into two Kinds, viz. Common Phosphorite, and Earthy Phosphorite.

First Kind.

Common Phosphorite, *Jameson.* Gemeiner Phosphorit, *Karsten.*

External Characters.—Colour yellowish-white, sometimes approaching to greyish-white. Occasionally spotted pale ochre-yellow, and yellowish-brown. Occurs massive, and in distinct concretions, which are thin and curved lamellar. Surface uneven and drusy. Dull or glistening. Cleavage imperfect curved, and generally floriform. Fracture uneven. Fragments indeterminate angular, and rather blunt-edged. Opaque, or feebly translucent on the edges.

Chemical Characters.—It becomes white before the blowpipe, and, according to Proust, melts with difficulty into a white-coloured glass. When rubbed in an iron mortar, it emits a green-coloured phosphoric light; and the same effect is produced when it is pounded and thrown on glowing coals.

Constituent Parts.—	Lime, ...	59 0
	Phosphoric Acid, .	34.0
	Silica, ...	2.0
	Fluoric Acid, . .	2.5
	Muriatic Acid, .	0.5
	Carbonic Acid, .	1.0
	Oxide of Iron, .	1.0—100.0

Pelletier, Journal des Mines, N. 166.

Geognostic and Geographic Situations.—It occurs in crusts, and crystallized, along with apatite and quartz, at Schlackenwald, in Bohemia, but most abundantly near Leigrosan, in the province of Estremadura, in Spain, where it is sometimes associated with apatite, and forms whole beds, that alternate with limestone and quartz.

Second Kind.

Earthy Phosphorite, *Jameson.* Erdiger Phosphorit, *Karsten.*

External Characters.—Colours greyish-white, greenish-white, and pale greenish-grey. Consists of dull dusty particles, which are partly loose, partly cohering, and which soil slightly, and feel meagre and rough.

Chemical Characters.—It phosphoresces when laid on glowing coals.

	Earthy Phosphorite from Marmarosch.	
Constituent Parts.—	Lime, ...	47 00
	Phosphoric Acid,	32.25
	Fluoric Acid, .	2.50
	Silica, ...	0.50
	Oxide of Iron, .	0.75
	Water, ...	1.00
	Mixture of Quartz and Loam. . .	11.50—95 50

Klaproth, Beit. b. iv. s. 373.

Geognostic and Geographic Situations.—It occurs in a vein, in the district of Marmarosch in Hungary.

Genus VI. LIMESTONE.

Kalk-Haloide. *Mohs.*

One and three axes. Cleavage di-prismatic; rhomboidal. Hardness ranges from 3.0 to 4.5. Sp. gr. = 2.5 — 3.2.

This genus contains four species, viz. 1. Prismatic or Arragonite. 2. Rhomboidal, or calcareous spar. 3. Short-axed, including dolomite and several varieties of rhomb-spar. 4. Long-axed. Rhomb-spar in part.

I. Prismatic Limestone, or Arragonite, *Jameson.* Prismatischer Kalk-Haloide, *Mohs.* Arragon, *Werner.*

Vertical prism = 115° 56′; horizontal prism in the direction of the shorter diagonal 109° 28′. The cleavage is the same, but most distinct in the direction of the smaller diagonal of the vertical prism. Hardness = 3.5, — 4.0. Sp. gr. = 2.6, — 3.0.

This species is divided into two subspecies, viz. Common Arragonite, and Coralloidal Arragonite.

First Subspecies.

Common Arragonite, *Jameson.* Gemeiner Arragon, *Werner.*

External Characters.—Colours white, grey, green, and violet-blue. In some crystals, green and blue colours occur together, and sometimes also grey. Occurs massive, and in distinct concretions, which are thick, thin, and very thin prismatic, and sometimes scopiformly diverging. It is frequently crystallized.

The following are some of its secondary figures:

1. Irregular six-sided prism, frequently with four lateral edges of about 116°, and two of 128°; or with three lateral edges of 128°, two of 116°, and one of 104°. These are formed by the grouping of several oblique four-sided prisms, bevelled on the extremities. Sometimes this prism is so flat, that it appears like a table.
2. Six-sided table.

    When, on the contrary, the long six-sided prism becomes acicular, there is formed

3. Long, and generally acicular double six-sided pyramids.

The crystals are middle-sized and small; they are generally attached by their terminal planes, seldomer by their lateral planes; sometimes imbedded, and are to be observed intersecting each other. Lateral planes of the crystals sometimes smooth, more frequently more or less deeply streaked or grooved. Terminal planes seldom smooth, generally uneven and rough, and sometimes also deeply notched. External lustre varies from dull to shining, and is vitreous: internally shining and glistening, and vitreous, inclining to resinous. Fracture small and imperfect conchoidal, passing into uneven. Fragments indeterminate angular, and rather sharp-edged; in the prismatic varieties splintery. Translucent, passing into semi-transparent, and refracts double. Brittle, and easily frangible.

Chemical Characters.—If we expose a small fragment to the flame of a candle, it almost immediately splits into white particles, which are dispersed around the flame. This change takes place principally with fragments of transparent crystals, fragments of the other varieties becoming merely white and friable. Fragments of calcareous-spar, when placed in a similar situation, undergo no alteration. Completely soluble, with effervescence, in the nitric and muriatic acids.

Constituent Parts.

From Molina in Arragon.

Carbonate of Lime, . .	94.5757	
Carbonate of Strontian, .	3.9662	
Hydrate of Iron, . . .	0.7060	
Water of Crystallization, .	0.3000	99.5489

Stromeyer, in Gilbert's Annalen der Physik, xiv. 217. October, 1813.

Geognostic and Geographic Situations.—*Europe.* It occurs along with galena in the lead mines of Leadhills, and in secondary trap-rocks in different parts of Scotland. It is one of the many interesting minerals met with in the secondary trap-rocks of the island of Iceland, and in the trap-rocks of the Department of the Puy de Dome, of Caupenne near Dax, and at Bastanes in Bearn, all in France.—*America.* It is found in the trap-rocks in Kannioak in North Greenland, and in the Haasen Island, also in North Greenland. Specimens of it have been met with at Guanaxuato in Mexico, but not in Peru.—*Asia.* It occurs in the trap-rocks of Van Diemen's Land, and in the neighbouring islands.—*Africa.* It is enumerated amongst the simple minerals contained in the trap or lava rocks of the isle of Bourbon.

Second Subspecies.

Coralloidal Arragonite.—*Jameson.*

External Characters.—Its most frequent colours are varieties of white. It occurs massive, reniform, tuberose, coralloidal, imperfect globular; in distinct concretions, which are fibrous, generally straight, seldom curved, and stellular and scopiform; sometimes also in reniform curved lamellar, and large angulo-granular concretions. Lustre glimmering, or glistening and pearly. Fracture fine splintery. Fragments wedge-shaped and splintery. Translucent, or translucent on the edges. In other characters, agrees with the preceding subspecies.

Geognostic and Geographic Situations.—It is found in Dufton Fell in Cumberland, also in the iron mines of Stiria and Carinthia, and at St. Marié aux Mines.

II. Limestone, *Jameson.*—Rhomboedrischer Kalk-Haloide, *Mohs.*

Rhomboid = 105° 5′. The most perfect cleavages are in the direction of the faces of the primitive rhomboid: less perfect in the direction of a flatter rhomboid; a third still less perfect, which is parallel with the planes of a six-sided prism; and a fourth, the most imperfect, which is parallel with the terminal planes of the six-sided prism. Hardness = 3.5. Sp. gr. = 2.5, — 2.8.

This species is divided into twelve subspecies, viz. 1. Foliated Limestone; 2. Compact Limestone; 3. Chalk; 4. Agaric Mineral; 5. Fibrous Limestone; 6. Calc-Tuff; 7. Peastone; 8. Slate-Spar; 9. Aphrite; 10. Lucullite; 11. Marl; 12. Bituminous Marl Slate.

First Subspecies.

Foliated Limestone, Jameson.—Blättriger, Kalkstein, *Werner.*

This subspecies is divided into two kinds, viz. Calcareous-spar, and Foliated Granular Limestone.

First Kind.

Calcareous-spar, or Calc-spar, *Jameson.*—Kalkspath, *Werner.*

External Characters.—Its colours are white, grey, red, blue, green, yellow, yellowish-brown, and greyish-black. White and grey varieties occur more frequently in the massive; yellow, green, and red, in those which are crystallized. White-coloured transparent varieties are often iridescent. It occurs massive, disseminated, globular, botryoidal, reniform, tuberose, stalactitic, tubular, cellular, and curtain-shaped; also in distinct concretions, which are large coarse, rarely small, angulo-granular; sometimes very thick, thick and thin, prismatic, generally wedge-shaped prismatic; always straight; sometimes parallel, sometimes scopiform prismatic; and these are intersected by lamellar concretions, which are fortification-wise bent, and very frequently crystallized. The suite of crystallizations of calcareous-spar far exceeds in extent that of any other mineral hitherto discovered.* The principal varieties are by Werner, according to his method, brought under three classes or subdivisions, which not only form series amongst themselves, but are connected together in such a manner, that the last member of the third class joins with the first member of the first class, and thus the whole forms a very beautiful returning series. Each of these divisions have their characteristic crystalline form, viz. The first an *acute double six-sided pyramid;* the second an *equiangular six-sided prism*, (including the six-sided table;) and the third a *rhomboid* or *three-sided pyramid.*

I. *Acute six-sided Pyramid.*

When perfect, it is always acute, and two and two lateral planes meet under obtuser angles than the others. It is generally obliquely streaked, but the streaks run from the acute towards the obtuse edges.

It occurs,

A. Single.

B. Double. The lateral planes of the one set obliquely on the lateral planes of the other, so that the edge of the common base forms a zig-zag line.

These pyramids occur either perfect, or in the following varieties:

1. The apex acuminated with three planes, which are set on the obtuse lateral edges. These are parallel with the cleavage.
2. The apex flatly acuminated with three convex faces, which are set on the acute lateral edges. The convexity is in the direction of the axis of the double pyramid.
3. The angles on the common base of the double pyramid truncated, thus forming a transition into the six-sided prism.
4. The acute lateral edges of the double pyramid sometimes truncated, and either with straight and smooth planes, or with convex and uneven planes.
5. Twin-crystal.

The double six-sided pyramids apparently pushed into each other in the direction of their length, in which they are either

(1.) *Unchanged* in position, when the acute edges rest on the obtuse edges; or they are

(2.) *Turned around* one-sixth of their periphery, so that obtuse edges are set on obtuse edges, and acute edges on acute edges; and the alternate angles on the common base have broken re-entering angles; or the angles on the common basis are truncated, and thus a transition is formed into the next following principal form.

II. *Equiangular six-sided Prism.*

It is equiangular, but generally with alternate broad and narrow lateral planes. It originates from the pyramid No. 3.; and hence it presents the following varieties:

1. The equiangular six-sided prism, acutely acuminated with six planes, of which two and two meet under obtuse angles, and each is set obliquely on the lateral edges. Sometimes the acute acuminating edges are truncated, or they are bevelled, and the edges which the bevelling planes make with the broad lateral planes, truncated.
2. In other varieties, the apices of the acuminations are more or less deeply truncated, and sometimes so deeply, that the acuminating planes appear as truncating planes on the angles of the prism.
3. The preceding figure, in which the six-planed acumination is *flatly acuminated* with three planes, which are set on the acute edges of the six-planed acumination.
4. Six-sided prism *acutely acuminated* with three planes which are set on the alternate lateral planes. The apex of the acumination is sometimes more or less deeply truncated. Sometimes the truncation is so deep, that the remains of the acuminating planes appear as truncations on the alternate terminal edges. In other varieties the prism becomes so short, that the acuminating planes meet and form an acute double three-sided pyramid.
5. When the planes of the flat three-planed acumination N° 3. increase so much that those of the six-planed acumination disappear, a six-sided prism is formed, *flatly acuminated* with three planes, which are set on the alternate lateral planes in an unconformable position. When the prism disappears, there is formed an obtuse double three-sided pyramid.

   These prisms are often pyramidally aggregated.
6. When the prism becomes very low, it may be viewed as an equiangular six-sided table, which is sometimes aggregated in a rose-like form.
7. Sometimes the six-sided prism is truncated on the lateral edges, and thus forms a twelve-sided prism. The prisms are aggregated in a pyramidal, manipular, scopiform, and tabular manner.

III. *Three-Sided Pyramid.*

It is divided, according to the magnitude of the summit-angle, into the following varieties:

1. *Very obtuse three-sided pyramid*, nearly tabular. It is sometimes aggregated in a rose-like form.
2. *Flat three-sided pyramid*, in which the lateral planes of the one are set on the lateral edges of the other. The angles on the common basis are sometimes truncated, and frequently the apices of the pyramid are more or less deeply truncated. When the truncation

* Romé de Lisle enumerates 26 varieties of calcareous-spar—Haüy above 150—and Bournon 642. Many more might be described.

on the apices is very deep, the crystal appears as a six-sided table, in which the terminal planes are set on alternately oblique.

3. *Acute three-sided pyramid.* This form very nearly resembles the cube.

It would extend this description too much, were we to attempt to give an account of every variety of form exhibited by these crystals; and besides, we have already enumerated the principal ones. The crystals occur of various magnitudes, as large, small, and very small. The lateral planes of the prisms and pyramids are generally shining, splendent, and smooth; the acuminating planes frequently streaked or drusy, seldom granulated. Sometimes it occurs in extraneous external forms of shells, &c. Internally it is generally specular splendent, or shining, sometimes glistening, and the lustre is vitreous, which inclines sometimes to resinous, and more rarely to pearly. Fracture perfect conchoidal. Fragments indeterminate angular, and rather sharp-edged, or they are rhomboidal. Occurs transparent, semi-transparent, and occasionally only translucent. It refracts double.* Brittle, and very easily frangible.

Chemical Characters.—It is infusible before the blow-pipe, but it becomes caustic, losing by complete calcination about 43 per cent.; effervesces violently with acids.

Constituent Parts.

	Iceland Spar.	Iceland Spar.	Iceland Spar.	From Andreasberg.
Lime, - -	56.15	55.50	56.50	55.9802
Carbonic Acid -	43.70	44.00	43 00	43.5635
Water - -		0.50	0.50	0.1000
Oxide of Manganese, with trace of Iron,	0.15			0.3562
	100.00	100 00	100 00	100.0000
	Stromeyer, Gilbert's Annalen for 1813, p. 217.	*Philips*, Phil. Mag. xiv. 290.	Gehl. *Bucholz*, Journ. iv. 412.	*Stromeyer*, Gilbert's An. for 1813, p. 217.

Geognostic Situation.—It never occurs in mountain-masses, but venigenous in almost every rock, from granite to the newest secondary formation.

An interesting geognostic character of calcareous-spar, is the uniformity of its crystallizations in particular districts. Thus, in the mines of Derbyshire, the acute six-sided pyramid and its congenerous forms are the most frequent and abundant; at Schneeberg in Saxony, and in the Upper Hartz, the prevailing forms are the regular six-sided prism and table; while in the mines of Freyberg, the most frequent forms are the regular six-sided prism, acuminated with three planes, set on the lateral planes, and the flat double three-sided pyramid.

Geographic Situation.—This mineral is so common in every country, as to render any account of its geographic distribution unnecessary.

Second Kind.

Granular Foliated Limestone, *Jameson.*—Blättriger Körniger Kalkstein, *Werner.*

External Characters.—Its most common colour is white, grey, red, yellow, and green. Has generally but one colour; sometimes, however, it is spotted, dotted, clouded, striped, and veined. Occurs massive, and in angulo-granular distinct concretions. Internally alternates from shining to glistening, and glimmering; lustre intermediate between pearly and vitreous. Fracture foliated, but sometimes inclines to splintery. Fragments indeterminate angular, and rather blunt-edged. More or less translucent. Brittle, and easily frangible.

Chemical Characters.—It generally phosphoresces when pounded, or when thrown on glowing coals. It is infusible before the blow-pipe. It dissolves with effervescence in acids.

Constituent Parts.—	Lime,	.	56.50
	Carbonic Acid,		43.00
	Water,	.	0.50—100

Bucholz, in Neuen Journal der Chem. iv. s. 419.

Geognostic Situation.—This mineral occurs in beds, in granite, gneiss, mica slate, clay-slate, syenite, greenstone, grey-wacke, and rarely in some of the secondary rocks.

Geographic Situation.—This mineral occurs in all the great ranges of primitive rocks that occur in Europe, and in such as have been examined in Asia, Africa, and America.

Uses.—All the varieties of this subspecies may be burnt into quicklime; but it is found, that in many of them, the concretions exfoliate and separate during the volatilization of their carbonic acid, so that by the time when they are rendered perfectly caustic, their cohesion is destroyed, and they fall into a kind of sand,—a circumstance which will always render it improper to use such varieties in a common kiln. But the most important use of this mineral is as marble. These marbles have been known from a very early period; and ancient statuaries have immortalised their names, by the masterpieces of art which they have executed in them. Of the ancient marbles, the most celebrated are those of Paros, Pentelicus, and Carrara. Marbles of different descriptions occur in Scotland, England, and Ireland, as appears from the following enumeration.

Scottish Marbles.

The Marbles of this part of Great Britain have hitherto been but little attended to, although it is highly probable that many valuable varieties occur in the different primitive and transition districts. At present, we shall mention a few of the best known varieties.

1. *Tiree Marble.*—Of this marble there are two varieties, viz. the Red and White.

a. Red Tiree Marble.—This is one of the most highly prized of the Scottish marbles. Its colours are red, of various tints, such as rose-red and flesh-red; also reddish-white; its lustre is glimmering; and the fracture is minute foliated, accompanied with splintery. It is very faintly translucent, or only highly translucent on the edges. It is always intermixed with different other earthy minerals, that add to its beauty, and give it a peculiar appearance. The most frequent of the imbedded minerals is common hornblende; the others are pale-green sahlite, blackish-brown mica, and green chlorite. In some varieties the hornblende is so abundant, that at first sight they might be confounded with syenite: in others, where nearly the whole mass is of hornblende, it would be considered as a variety of hornblende rock.

b. White Tiree Marble.—Its colours are greyish-

* The double refracting power of calcareous-spar was first observed by Erasmus Bartholin.

white and bluish-white: it contains scales of mica, and crystals or grains of common hornblende; which latter, when minutely diffused, give the marble a green or yellowish-green colour, and, when very intimately combined with the mass, form beautiful yellowish-green spots.

2. *Iona Marble.*—Its colours are greyish-white and snow-white. Its lustre is glimmering, and fracture minute foliated, combined with splintery. It is harder than most of the other marbles. It is an intimate mixture of limestone and tremolite; for if we immerse it in an acid, the carbonate of lime will be dissolved, and the fibres of tremolite remain unaltered. It is sometimes intermixed with steatite, which gives it a green or yellow colour, in spots. These yellow or green-coloured portions receive a considerable polish, and have been erroneously described as nephritic stone, and are known also under the name of *Iona* or *Icolmkill Pebbles.* The marble itself does not receive a high polish: this, with its great hardness, have brought it into disrepute with artists. Several of the varieties of Iona marble are dolomite.

3. *Skye Marble.*—In the Island of Skye, in the property of Lord Macdonald, there are several varieties of marble, deserving of attention, inclosed in porphyry, sandstone, and trap-rocks. One variety is of a greyish inclining to snow-white colour: another greyish-white, veined with ash-grey; and a third is ash-grey, or pale bluish-grey, veined with lemon-yellow or siskin-green. Dr. M'Culloch has described other varieties; and more minute details are expected from his promised work on the "Geology of the Hebrides."

4. *Assynt.*—The following varieties of marble, found in Sutherland, have been introduced into commerce by Mr. Joplin of Gateshead.

a. White marble, which acquires a smooth surface on the polisher, but remains of a dead hue, like the marble of Iona: hence its uses as an ornamental marble are much circumscribed.

b. White mottled with grey, and capable of receiving a high polish, and is not deficient in beauty.

c. Grey-coloured, and highly translucent and crystalline, and capable of being applied to the purposes of ornament in sepulchral sculpture.

d. Dove-coloured, compact, translucent, and receiving a good polish.

e. Pure white, and translucent, and capable of being used in plain ornaments; but too translucent for sculpture.

f. White, with irregular yellow marks, from being intermixed with serpentine. It is very compact.

g. White variety, with layers of slate-spar.

5. *Glen Tilt Marble.*—The limestone of Glen Tilt, first mentioned by Dr. Macknight, in his description of that valley, has of late attracted the notice of the Duke of Athole, through the suggestion of Dr. M'Culloch. The marbles are white and grey, and veined or spotted with yellow or green: they vary in the size of the grain or concretion, and also in the degree and kind of polish they receive.

6. *Marble of Ballichulish.*—This marble is of a grey or white colour, and is very compact. It may be raised in blocks of considerable size.

7. *Boyne Marble.*—Its colours are grey or white, and it receives a pretty good polish.

8. *Blairgowrie Marble.*—Mr. Williams, in his Natural History of the Mineral Kingdom, mentions a beautiful saline marble, of a pure white colour, which occurs near Blairgowrie in Perthshire, not far from the road side. According to him, it may be raised in blocks and slabs, perfectly free of blemishes, and in every respect fit to be employed in statuary and ornamental architecture.

9. *Glenavon Marble,*—is of a white colour, and the concretions are large granular. It is mentioned by Williams as a valuable marble; but he adds, that its situation is remote, and difficult of access.

English Marbles.

Hitherto but few marbles of granular foliated limestone have been quarried in England; the greater number of varieties belonging to the flœtz or secondary limestone. One of the most remarkable of the English marbles of the present class, is that of Anglesea, named *Mona Marble*, which is not unlike the *Verde Antico.* Its colours are greenish-black, leek-green, and sometimes purple, irregularly blended with white; but they are not always seen together in the same piece. The white part is limestone: the green shades are said to be owing to serpentine and asbestus. The Black Marbles found in England, are varieties of Lucullite.

Irish Marbles.

The Black Marbles of Ireland, now so generally used by architects, are Lucullites. In the county of Waterford, different kinds of marble are known; thus at Toreen, there is a fine variegated sort, of various colours, viz. chesnut-brown, white, yellow, and blue, and which takes a good polish: a grey marble, beautifully clouded with white, susceptible of a good polish, has been found near Kilcrump, in the parish of Whitechurch, in the same county. At Loughlougher, in the county of Tipperary, a fine purple marble is found, which, when polished, is said to be beautiful. Smith describes several variegated marbles in the county of Cork; but whether these, and others now enumerated as Irish marbles, are granular limestone, I cannot discover, as I have neither met with good descriptions of them, nor seen any specimens. Thus, he mentions one with a purplish ground, and white veins and spots, found at Churchtown; a bluish and white marble from the same place; and several fine ash-coloured varieties, as that of Castle Hyde, &c. The county of Kerry affords several variegated marbles, such as that found near Tralee. Marble of various colours is found in the same county, in the islands near Dunkerron, in the river of Kenmare: some are purple and white, intermixed with yellow spots; and some beautiful specimens have been seen, of a purple colour, veined with dark-green.

Second Subspecies.

Compact Limestone, *Jameson.*—Dichter Kalkstein, *Werner.*

This Subspecies is divided into three kinds, viz. Common Compact Limestone, Blue Vesuvian Limestone, and Roe-stone.

First Kind.

Common Compact Limestone, *Jameson.*—Gemeiner Dichter Kalkstein, *Werner.*

External Characters.—Most frequent colour grey, greyish-black, yellow, and red. Frequently exhibits veined, zoned, striped, clouded, and spotted coloured delineations; and sometimes also black and brown coloured arborisations. It very rarely exhibits a beautiful play of colours, caused by intermixed portions of pearly shells. Occurs massive, corroded, in large plates, rolled masses, and in various extraneous external shapes, of univalve, bivalve, and multivalve shells, of corals, fishes, and more rarely of vegetables, as of ferns and reeds. Internally dull, seldom glimmering, which is owing to intermixed calcareous-spar. Fracture small and fine splintery, which sometimes passes into large and flat conchoidal, sometimes into uneven, inclining to earthy, and it occasionally inclines to straight and thick slaty. Fragments indeterminate angular, more or less sharp-edged, but in the slaty variety they are tabular. Generally translucent on the edges, sometimes opaque. In general rather softer than granular foliated limestone. Brittle, and easily frangible. Streak generally greyish-white.

Specific gravity, Splintery, 2.600, 2.720, *Brisson.* Opalescent Shell Marble, 2.673, *Leonhard.*—2.675, *Werner.*

Chemical Characters.—It effervesces with acids, and the greater part is dissolved; and burns to quick-lime, without falling to pieces.

Constituent Parts.

Rudersdorf.		*Bluish-grey Limestone.*		*Limestone from Sweden.*		*Limestone from Ettersberg*	
Lime,	53.00	Lime,	49.50	Lime,	49.25	Lime,	33.41
Carbonic Acid,	42.50	Carbonic Acid,	40.00	Carbonic Acid,	35.00	Carbonic Acid,	42.00
Silica,	1.12	Silica,	5.25	Silica,	8.75	Silica,	10.25
Alumina,	1.00	Alumina,	2.75	Alumina,	2.50	Magnesia,	9.43
Iron,	0.75	Iron,	1.37	Iron,	2.75	Iron,	2.25
Water,	1.03	Water,	1.13	Loss,	1.75	Manganese,	1.25
						Loss,	1.41
	100		100		100		100
Simon, Gehlen's Jour. iv. s. 426.		*Simon*, Ib.		*Simon*, Ib.		*Bucholz*, Ib.	

Geognostic Situation.—This mineral occurs in vast abundance in nature, principally in secondary formations, along with sandstone, gypsum, and coal; but in small quantity in primitive mountains.

Geognostic Situation.—It abounds in the sandstone and coal formations, both in Scotland and England; and in Ireland, it is a very abundant mineral in all the districts where clay-slate and red sandstone rocks occur. On the Continent of Europe, it is a very widely and abundantly distributed mineral; and forms a striking feature in many extensive tracts of country in Asia, Africa, and America, as will be particularly described in the Geognostic part of this article.

Uses.—When compact limestone joins to pure and agreeable colours, so considerable a degree of hardness that it takes a good polish, it is by artists considered as a Marble; and if it contains petrifactions mineralized, it is named *shell* or *lumachella*, and *coral* or *zoophytic marble*, according as the organic remains are testaceous or coralline*. In one particular variety of lumachella or shell marble, found at Bleiberg in Carinthia, the shells and fragments of shells, which belong to the nautilus tribe, are set in a brown coloured basis, and reflect many beautiful and brilliant pearly inclining to metallic colours, principally the fire-red, green, and blue tints. It is named *opalescent* or *fire marble*. Another lumachella marble from Astracan, contains, in a reddish-brown basis, pearly shells of nautili, that reflect a very brilliant gold-yellow colour. In some compact marbles, the surface presents a beautiful arborescent appearance, and these are naturally *arborescent* or *dendritic marbles*. Such as those of Papenheim in Bavaria.

The *Florentine Marble*, or *Ruin Marble*, as it is sometimes called, is a compact limestone. It occurs on the Po and the Arno, and is worked into various articles at Florence. To the same compact limestone may be referred the variety called *Cottam Marble*, from being found at Cottam, near Bristol. It resembles in many respects the landscape marble.

In different parts of Scotland, compact limestone is cut and polished as marble: this was the case in the parish of Cummertrees in Dumfriesshire,—in Cambusland parish, in Lanarkshire,—in Fifeshire, &c. In England, many compact limestones are cut and polished as marbles; such are the limestones of Derbyshire, Yorkshire, Devonshire, Somersetshire, and Dorsetshire. It is sometimes used as a building stone, and, in want of better materials, for paving streets, and making highways. When, by exposure to a high temperature, it is deprived of its carbonic acid, and converted into quicklime, it is used for mortar; also by the soap-maker, for rendering his alkalies caustic; by the tanner, for cleansing hides, or freeing them from hair, muscular substance, and fat; by the farmer, in the improvement of particular kinds of soil; and by the metallurgist, in the smelting of such ores as are difficultly fusible, owing to an intermixture of silica and alumina.

Second Kind.

Blue Vesuvian Limestone, *Jameson.*—Blauer Vesuvischer Kalkstein, *Klaproth.*

External Characters.—Colour dark bluish-grey, partly veined with white. Externally it appears as if it had been rolled; and the surface is uneven. Fracture fine earthy, passing into splintery. Is opaque. Affords a white streak.

Const. Parts.—Lime,		58.00
	Carbonic Acid,	28.50
	Water, which is somewhat ammoniacal,	11.00
	Magnesia,	0.50
	Oxide of Iron,	0.25
	Carbon,	0.25
	Silica,	1.25—99.75

Klaproth, Beit. b. v. s. 96.

From this analysis, it appears, that the vesuvian limestone differs remarkably in composition from common compact limestone. In common compact limestone, 100 parts of lime are combined with at least 80 parts of carbonic acid; whereas in the vesuvian limestone, 100 parts of limestone are not combined with more than 50 parts of carbonic acid. Secondly, In common limestone, independent of the water which adheres to it accidentally, as far as we know, there is no water of composi-

* The name *marmor* is derived from the Greek μαρμαιρειν, *to shine*, or *glitter*, and was by the ancients applied, not only to limestone, but also to stones possessing agreeable colours, and receiving a good polish, such as gypsum, jasper, serpentine, and even granite and porphyry.

tion; but in the vesuvian limestone there are 11 parts of water of composition.

Geographic Situation.—This remarkable limestone is found in loose masses amongst unaltered ejected minerals in the neighbourhood of Vesuvius.

Observations.—It is known to some collectors under the name *Compact Blue Lava* of Vesuvius; and is sometimes employed by artists in their mosaic work, to represent the sky.

Third Kind.

ROESTONE, or OOLITE *Jameson**.—Roogenstein, *Werner.*

External Characters.—Colours brown and grey. Occurs massive, and in distinct concretions, which are round granular; the larger are composed of fine spherical granular, and sometimes of very thin concentric lamellar concretions. Internally dull. Fracture of the grains fine splintery; but of the mass round granular in the small, and slaty in the large. Fragments in the large blunt-edged. Is opaque. Rather brittle, and very easily frangible. Sp. gr. 2.6829, 2.6190, *Kopp.*—2.585 *Breithaupt*

Chemical Characters.—It dissolves with effervescence in acids.

Geognostic Situation.—It occurs along with red sandstone, and *lias* limestone.

Geographic Situation.—This rock, which, in England, is known under the names Bath-stone, Ketton-stone, Portland-stone, and Oolite, extends, with but little interruption, from Somersetshire to the banks of the Humber in Lincolnshire. On the Continent of Europe, it occurs in Thuringia, the Netherlands, the mountains of Jura, and in other countries.

Uses.—The Oolite, or Roestone, particularly that of Bath and Portland, is very extensively employed in architecture; it can be worked with great ease, and has a light and beautiful appearance; but it is porous, and possesses no great durability, and should not be employed where there is much carved or ornamental work, for the fine chiselling is soon effaced by the action of the atmosphere. On account of the ease and sharpness with which it can be carved, it is much used by the English architects, who appear to have little regard for futurity. St. Paul's is built of this stone, also Somerset-House. The Chapel of Henry VIII. affords a striking proof of the inattention of the architects to the choice of the stone. All the beautiful ornamental work of the exterior had mouldered away in the short comparative period of 300 years. It has recently been cased with a new front of Bath-stone, in which the carving has been correctly copied: from the nature of the stone, we may predict, that its duration will not be longer than that of the original. Both Portland and Bath-stone varies much in quality. In buildings constructed of this stone, we may frequently observe some of the stones black, and others white. The black stones are those which are more compact and durable, and preserve their coating of smoke: the white stones are decomposing, and presenting a fresh surface, as if they had been recently scraped. Roestone is also used as a manure, but when burnt into quicklime, the marly varieties afford rather an indifferent mortar; but those mixed with sand a better mortar.

THIRD SUBSPECIES.

CHALK, *Jameson.*—Kreide, *Werner.*

External Characters.—Colour yellowish-white, sometimes passes to greyish-white and snow-white. It is sometimes marked with yellowish-grey. Occurs massive, disseminated, in crusts, and in extraneous external shapes. Is dull. Fracture coarse and fine earthy. Fragments blunt-edged. Opaque. Writes and soils very much. Soft, and sometimes very soft. Rather sectile, and easily frangible. Adheres slightly to the tongue. Feels very meagre, and rather rough. Specific gravity, 2.252 *Muschenbroeck.*—2.315, *Kirwan.*—2.657 *Watson*—2.226. *Breithaupt.*

Chemical Characters.—It effervesces strongly with acids.

Constituent Parts.

		Chalk from Gallicia.			
Lime, .	56.5	Lime, .	47.00	Lime, .	53
Carbonic Acid,	43.0	Carbonic Acid,	33.00	Carbonic Acid,	42
Water, .	0.5	Silica, .	7.00	Alumina,	2
	——	Alumina,	2.00	Water, .	3
		Magnesia,	8.00		——
Bucholz, in Gehlen's Journ. b. iv. s. 416.		Iron, .	0.05		
			——	*Kirwan*, Min. vol. i. p. 77.	
		Hacquet.			

Geognostic Situation.—It constitutes one of the newer secondary or floetz formations; is usually found in low situations, and frequently on sea-coasts. It is stratified, and the strata in general are horizontal. It often contains flint, which is disposed either in interrupted beds in the chalk, or in globular, tuberose, or tabular masses imbedded in it. It abounds in organic remains, and these are principally of animals of the lower orders, such as echinites, belemnites, terebratulites, pinnites, &c.

Geographic Situation.—It abounds in the south-eastern parts of England,—extends through several provinces in France,—occupies great tracts of country in Poland and Russia,—is met with on the shores of the Baltic,—and in the islands of Zeeland and Rugen.

Uses.—The uses of this mineral are various. The more compact kinds are employed as building-stones, when they are used either in a rough state, or are sawn into blocks of the requisite size and shape: it is burnt into quicklime, and used for mortar in different countries; thus, nearly all the houses in London are cemented with chalk-mortar†: it is also employed in great quantities in the polishing of glass and metals, and whitening the roofs of rooms, in the state of *whiting*‡; in constructing moulds to cast metal in; by carpenters and others as a material to mark with. When perfectly purified, and mixed with vegetable colours, it forms a kind of pastil colour: thus, with litmus, turmeric, saffron, and sap-green, it forms durable colours, but vegetable colours that contain an acid, become blue when mixed with it. The *Vienna white* known to artists, is perfectly purified chalk. It is used by starch-makers and chemists to dry precipitates on, for which it is peculiarly qualified, on account of the remarkable facility

* *Roestone*, so named on account of its resemblance in form to the roe of fishes.

† According to Smeaton, it makes as good lime as the best limestone or marble.

‡ In the preparation of whiting, chalk is pounded, and diffused through water, and the finer part of the sediment is then dried; by this means, the siliceous particles are separated, which, by their hardness, would scratch the surface of metallic and other surfaces, in the polishing of which whiting is used.—Aikin's *Chem. Dictionary*.

with which it absorbs water. With isinglas, or white of eggs, it forms a valuable lute or cement. In the gilding of wood, it is necessary, before laying on the gold, to cover it with a succession of coats of a mixture of whiting and size. The mineral is also used as a filtering-stone; and in a purified state, it is employed as a remedy to correct acidity in the stomach, and the morbid states which arise from this.

Fourth Subspecies.

Agaric Mineral, or Rock Milk, *Jameson.*—Berg-Milch *Werner.*

External Characters.—Colours snow-white, greyish-white, and yellowish white. Occurs frequently in crusts, also in loosely cohering tuberose pieces. Dull. Composed of fine dusty particles. Soils strongly. Feels meagre. Adheres slightly to the tongue. Very light, almost supernatant.

Chemical Characters.—It effervesces with acids, and is completely dissolved in them.

Constituent Parts.—It is a pure carbonate of lime.

Geognostic and Geographic Situations.—It is found on the north side of Oxford, between the Isis and the Cherwell, and near Chipping-Norton, also in Oxfordshire.

Fifth Subspecies.

Fibrous Limestone, *Jameson.*—Fasriger Kalkstein, *Werner.*

This subspecies is divided into two kinds, viz. Common Fibrous Limestone, or Satin-Spar, and Fibrous Calc-Sinter.

First Kind.

Common Fibrous Limestone, or Satin-Spar, *Jameson.*—Gemeiner fasriger Kalkstein, *Werner.*

External Characters.—Colours greyish, reddish, and yellowish-white. Occurs massive, also in distinct concretions, which are coarse and fine fibrous, and either straight or curved. Lustre glistening or shining, and pearly. Fragments splintery. Feebly translucent. As hard as calcareous-spar. Easily frangible. Specific gravity 2.70, *Pepys.*

Constituent Parts.

Carbonate of Lime,	95.75	Lime, .	50.8
Carbonate of Manganese,	4.25	Carbonic Acid,	47.6
			98.4
	Holme.		*Pepys*, in Kid's Min. vol. i. p. 49.

Stromeyer says that fibrous limestone contains some *per cents.* of gypsum.

Geognostic and Geographic Situations.—It occurs in thin layers in clay-slate at Aldstone Moore in Cumberland; in layers and veins in the middle district of Scotland, as in Fifeshire. On the Continent, at Potschappel, near Dresden, and at Schneeberg, also in Saxony.

Uses.—It is sometimes cut into necklaces, crosses, and other ornamental articles.

Second Kind.

Fibrous Calc-Sinter*, *Jameson.*—Fasriger Kalksinter, *Werner.*

External Characters.—Principal colours white, yellow, brown, grey, red, green, and blue. Sometimes concentrically and reniformly striped, or it is spotted or clouded. Occurs massive, stalactitic, globular, tubular, claviform, fruticose, curtain shaped, cock's-comb-shaped, coralloidal, reniform, and tuberose; also in distinct concretions, which are fibrous, and these are straight, seldom curved, and sometimes scopiform or stellular; also in reniform curved lamellar concretions, and seldom in large and coarse angulo-granular concretions; very rarely the longish external shapes, as the stalactitic, are terminated by a three-sided pyramidal crystallization. Surface generally rough, and seldom fine drusy. Internally glimmering, which passes on the one side into dull, on the other into glistening; and the lustre is pearly. Fracture fine splintery. Fragments splintery, or wedge-shaped. Translucent, or only translucent on the edges.

Constituent Parts.—	Lime . .	56.0	
	Carbonic Acid	43.0	
	Water . .	1.0	—100.0

Bucholz, in Gehlen's Journal, b. iv. s. 425.

Geognostic and Geographic Situations.—It is found encrusting the roofs, walls, and floors of caves, particularly those situated in limestone rocks. It is formed from water holding carbonate of lime in solution. Caves lined with this mineral occur in almost every country. Maccallister's Cave, in the island of Skye, and those in the limestone hills of Derbyshire, are the most striking appearances of this kind hitherto observed in Scotland and England. But the most celebrated stalactitic cave is that of Antiparos in the Archipelago, which has been particularly described by Tournefort. Similar caves occur in Germany, France, Switzerland, Spain, in the United States of America, and other countries. Italy, which is so rich in fine marble, is not less so in beautiful calc-sinter or calcareous alabaster; the territory of Volterra in Tuscany alone furnishes no fewer than twenty different varieties. Sicily is also abundant in calc-sinter; and of these, the rose-coloured variety of Trapani is much admired. Spain is, next to Italy, the most productive country of calcareous alabaster. The environs of Granada and Malaga are particularly remarkable for the beautiful varieties of this mineral which they afford. Persia also abounds in highly prized varieties of calcareous alabaster.

Uses.—Calc-sinter, or calcareous alabaster, is used for the same purposes as marble, and is cut into tables, columns, vases, drapery for marble figures, and sometimes also into statues. It was also used by the ancients in the manufacture of their unguentary vases.

Sixth Subspecies.

Tufaceous Limestone Calc-tuff†, *Jameson.*—Kalk-Tuff. *Werner.*

External Characters.—Colour yellowish-grey, which sometimes approaches to ochre yellow and yellowish-brown. Occurs massive, perforated, ramose, spongy, tubular, claviform, botryoidal, globular, cellular, and in crusts; enclosing vegetable stems and leaves; also bones of animals, as of elephants and rhinoceroses, and land shells; and also with frequent impressions of leaves, mosses, and roots. The globular variety is sometimes composed of curved lamellar concretions.

* This is the Alabaster of the ancients, and is by the moderns named *Calcareous Alabaster*, to distinguish it from another mineral, gypsum, which they name *Gypseous Alabaster*.

† The term *tufa* appears to be derived from the verb τύφω, which, in its original signification, is appropriate to volcanic productions, especially to such as are of a spongy or porous texture. *Kid.*

Internally dull, or very faintly glimmering. Fracture fine-grained uneven, inclining to earthy; and sometimes splintery. Fragments indeterminate angular. Opaque, or translucent on the edges. Sometimes semi-hard, sometimes soft, and is frequently soft, inclining to friable. Rough. Brittle, and easily frangible.

Constituent Parts.—It is nearly pure Carbonate of Lime.

Geognostic Situation.—It occurs in beds, generally in the neighbourhood of lakes and rivers: also encrusting rocks, and enveloping animal and vegetable remains in the vicinity of calcareous springs.

Geographic Situation.—It is a frequent mineral in the neighbourhood of all the calcareous springs in this country, as in those at Starly Burn in Fifeshire, and other places; and on the Continent of Europe it is also a frequent mineral.

Uses.—The hardest kinds are used for building-stones, and are also burnt into quicklime. It is sometimes also used as a filtering stone.

Seventh Subspecies.

Pisiform Limestone, or Pea-stone, *Jameson.*—Erbsenstein, *Werner.*

External Characters.—Its most common colour is yellowish-white, which sometimes approaches to snow-white; from yellowish-white it passes into pea-yellow, and pale-yellowish brown. Occurs massive; also in distinct concretions, which are coarse, small, and very seldom fine spherical round granular, composed of others which are very thin and concentric lamellar. In the centre there is either a bubble of air, or a grain of sand, or of some mineral matter. Internally dull, or very feebly glimmering. Fracture even. Fragments indeterminate angular, and blunt edged. Opaque, or feebly translucent on the edges. Soft, approaching to semi-hard Brittle, and very easily frangible. Specific gravity 2.552.

Constituent Parts.—It is carbonate of lime, slightly coloured with iron.

Geognostic and Geographic Situations.—It is found in great masses in the vicinity of the Hot Springs at Carlsbad in Bohemia.

Uses.—It is sometimes cut into plates for ornamental purposes.

Eighth Subspecies.

Slate-Spar, *Jameson.*—Schieferspath, *Werner.*

External Characters.—Colours greenish-white, reddish-white, yellowish-white, greyish-white, and snow-white. Occurs massive, also in distinct concretions, which are generally curved lamellar, and sometimes coarse and large granular. Lustre intermediate between shining and glistening, and is pearly. Fragments either indeterminate angular and blunt-edged, or are tabular. Feebly translucent, or only translucent on the edges. Soft. Intermediate between sectile and brittle. Easily frangible. Feels rather greasy. Specific gravity, 2.647, *Kirwan.*—2.474, *Blumenbach.*—2.6300, *La Methrie.*—2.611. *Breithaupt.*

Chemical Characters.—It effervesces very violently with acids: but is infusible before the blowpipe.

Constituent Parts.

From Bremsgrün.		From Kongsberg.	
Lime,	55.00	Lime,	56.00
Carbonic Acid	41.66	Carbonic Acid,	39.33
Oxide of Manganese,	3.00	Silica,	1.66
	———	Oxide of Iron,	1.00
Bucholz.		Water,	2.00
			———
		Suersee.	

Geognostic Situation.—It occurs in primitive limestone, along with calcareous spar, brown-spar, fluor-spar, and galena; in metalliferous beds, associated with magnetic ironstone, galena, and blende; and in veins, along with tinstone.

Geographic Situation.—It occurs imbedded in marble in Glen Tilt, Perthshire; and in Assynt in Sutherland: in Cornwall; and near Granard in Ireland. On the Continent, it is found along with tinstone, in the Saxon Erzgebirge; along with octahedrite, in a vein at St. Chirstophe in Dauphiny; also in Norway, in metalliferous beds, and in limestone.

Ninth Subspecies.

Aphrite, *Jameson.*—Schaumerde, *Werner.*

This subspecies is divided into three kinds, viz. Scaly Aphrite, Slaty Aphrite, and Sparry Aphrite.

First Kind.

Scaly Aphrite, *Jameson.*—Schaumerde, *Werner.* Zerreiblicher Aphrit, *Karsten.*

External Characters.—Colours snow, yellowish, and reddish white, sometimes passing into silver-white. Occurs either friable or compact. Friable varieties composed of glistening or glimmering particles, in which the lustre is pearly. Particles are fine scaly, feel fine, but not greasy. Either loose, or loosely cohering. Compact varieties massive, disseminated, or in granular concretions, with a shining or nearly splendent lustre, which is pearly, sometimes inclining to semi-metallic. Fragments indeterminate angular, and blunt edged in the great, but tabular in the small. Opaque. Soils slightly. Very soft, passing into friable. Sectile, and uncommonly easily frangible. Feels very fine, but not greasy.

Chemical Characters.—It effervesces most violently with acids.

Constituent Parts.—

Lime,	51 5
Carbonic Acid,	39.0
Silica,	5 715
Oxide of Iron,	3.285
Water,	1.0—100.5
	Bucholz.

Geognostic Situation.—It occurs in nests, disseminated, or in small veins, in flœtz or secondary lime-stone, and gypsum.

Geographic Situation.—It is found in Thuringia and Hessia.

Second Kind.

Slaty Aphrite, *Jameson.*—Schaumscheifer, *Friesleben.*

External Characters.—Colours snow-white, passing into yellowish, reddish, and silver-white. Occurs massive, seldom coarsely disseminated. Strongly glimmering, sometimes approaching to glistening, even to shining; lustre pearly; which sometimes passes into semi-metallic. Slaty in the great, but undulating curved foliated in the small. Splits very easily into extremely thin tabular fragments. Opaque, or very feebly translucent in the thinnest folia. Soils pretty strongly. Feels soft, and rather silky. Flexible in thin plates.

Chemical Characters.—It falls into pieces with a crackling noise, when put into water. When touched with an acid, it effervesces with great violence, and is entirely dissolved in it.

Geognostic and Geographic Situations.—It occurs massive, imbedded, and in veins, in the first flœtz limestone, in Thuringia and Hessia.

Third Kind.

Sparry Aphrite, *Jameson.*—Schaumspath, *Friesleben.*

External Characters.—Colours snow, yellowish, and greyish-white. Seldom occurs massive, generally disseminated; sometimes in flaky crusts, in veins, or imbedded in large crystals of selenite. Shining, sometimes inclining to splendent, sometimes to glistening; lustre pearly, which inclines to vitreous in the splendent varieties. Fracture foliated, sometimes straight, sometimes curved, and the folia have a single distinct cleavage. Opaque; feebly translucent in thin pieces. Occurs in large and small granular distinct concretions. Soils slightly, with glimmering dusty particles. Soft. Sectile.

Chemical Characters.—The same as in the other kinds.

Geognostic Situation.—It occurs in flœtz or secondary limestone and gypsum. According to Friesleben, it appears to be geognostically allied to selenite; and although it differs from that mineral in colour, transparency, lustre, sectility, feel, and effervescence with acids, yet it passes into it, and also into slaty aphrite, sometimes by simple gradations, sometimes by intermixture of the two minerals; and large lenticular crystals of selenite occur, which are pure at the edges, become gradually more opaque towards the centre, and in the centre are pure sparry aphrite.

Geographic Situation.—It occurs in Thuringia.

Tenth Subspecies.

Lucullite, *Jameson.*

This subspecies is divided into three kinds, viz. Compact Lucullite, Prismatic Lucullite, and Foliated Lucullite.

First Kind.

Compact Lucullite, *Jameson.*—Dichter Lucullan, *John.*

This kind is divided into Common Compact Lucullite, or Black Marble, and Stinkstone.

a. Common Compact Lucullite, or Black Marble, *Jameson.*

External Characters.—Colour greyish-black. Occurs massive. Internally strongly glimmering, inclining to glistening. Fracture fine-grained uneven, and large conchoidal. Fragments indeterminate angular, and rather sharp-edged. Opaque. Semi-hard. Yields a dark ash-grey coloured streak. Brittle, and easily frangible.

When two pieces are rubbed against each other, a fetid urinous odour is exhaled, the intensity of which is increased when we at the same time breathe on them.

Chemical Characters.—It is infusible without addition. When exposed to a high temperature in an open crucible, it burns white. With sulphuric acid, it forms a black-coloured mass: it dissolves in nitrous and muriatic acids, but leaves an insoluble black-coloured substance. During the solution and escape of the carbonic acid, a smell resembling that of sulphuretted hydrogen is evolved.

Constituent Parts.

Lime,	53.38
Carbonic Acid,	41.50
Black Oxide of Carbon,	0.75
Magnesia, and Oxide of Manganese,	0.12
Oxide of Iron,	0.25
Silica	1.13
Sulphur	0.25
Potash, combinations of Muriatic and Sulphuric Acids, and Water,	2.62—100.00

John, Chem. Laborat. b. ii. s. 240.

Geognostic Situation.—The geognostic relations of this mineral are still but little known: it is said to occur in beds in primitive and older secondary rocks.

Geographic Situation.—Hills of this mineral occur in the district of Assynt in Sutherland. Varieties of it are met with at Ashford, Matlock, and Monsaldale, in Derbyshire: at Kilkenney; at Crayleath, in the County of Down; at Kilcrump, in the county of Waterford; at Churchtown, in the county of Cork; and in the county of Galway, in Ireland.

Uses.—The finer varieties of this mineral have been highly prized, and used as marble from a very remote period. It was so much admired and esteemed by the Consul Lucullus, that he gave it his own name. Pliny observes: "Post hunc Lepidum ferme quadriennio L. Lucullus Consul fuit, qui nomen (ut apparet ex re) *Lucullео Marmori* dedit, admodum delectatus illo, primusque Romam invexit, atrum alioqui, cum cætera maculis aut coloribus commendentur. Nascitur autem in Nili insula, solumque horum marmorum ab amatore nomen accepit."

The finest varieties of lucullite met with in trade in this island, are the black marbles of Sutherlandshire, Kilkenney, and Galway.

b. Stinkstone, or Swinestone, *Jameson.* Stinkstein, *Werner.*

External Characters.—Its colours are white, grey, pitch-black, yellow, and brown. Sometimes dendritic on the surface, or clouded with greyish-black. Occurs massive, disseminated, also in distinct concretions, which are small granular, and concentric lamellar. Internally dull or glimmering. The fracture is sometimes small splintery, sometimes imperfect conchoidal, and fine grained uneven, which passes into earthy, or straight slaty. Fragments are indeterminate angular, or slaty. Opaque, but the cream-yellow varieties are translucent on the edges. Affords a greyish-white coloured streak, and when rubbed emits a fetid urinous odour. Brittle, and easy frangible.

Chemical Characters.—Nearly the same as in the preceding kind.

Constituent Parts.

	From Bottendorf.
Carbonate of lime	148—149.00
Silica	7.00
Alumina	5.25
Oxide of iron	2.50
Oxide of manganese	1.00
Oxide of carbon, and a little bitumen,	0.50
Lime,*	1.00
Sulphur, alkali, salt, water,	3.75—170.00

John, Chem. Laborat. t. ii. s. 242.

* We have copied the above analysis from Dr. John's work; yet we do not see how it is possible that 1 part of lime could be discovered along with 149 of carbonate of lime.

Geognostic Situation.—This mineral occurs in beds, in secondary limestone, and occasionally alternates with secondary gypsum, and beds of clay. In some places, the strata are quite straight, in others have a zig-zag direction, or are more or less deeply waved, and they are occasionally disposed in a concentric manner, like the concentric lamellar concretions of greenstone. Some strata contain angular pieces of stinkstone, which at first sight might be taken for fragments; and even whole beds occur, which are composed throughout of angular portions, either connected together by means of clay, or immediately joined without any basis. These various appearances do not seem to have been occasioned by any mechanical force acting upon the strata after their formation, but are rather to be viewed as original varieties of structure, which have taken place during the formation of the strata. It has been also met with in beds in shell limestone, and in the coal formation.

Geographic Situation.—Occurs in the vicinity of North Berwick in East Lothian, resting on red sandstone; and in the parish of Kirbean in Galloway. On the Continent, it is a frequent rock in Thuringia and Mansfeld.

Uses.—In ancient times, it was used as a medicine in veterinary practice: at present, it is principally employed as a limestone, and when burnt affords an excellent lime both for mortar and manure. In some districts, as in Thuringia, it is used as a paving-stone, and also cut into troughs, steps for stairs, door-posts, and other similar purposes.

Second Kind.

Prismatic Lucullite, *Jameson.*—Stänglicher Lucullan, *John.*

External Characters.—Colours greyish-black, pitch-black, smoke-grey, and hair-brown. Occurs massive, in balls, also in distinct concretions, which are stellular and scopiform prismatic. External surface sometimes delicately longitudinally streaked. Externally it is sometimes dull, sometimes glistening; internally shining and splendent, and the lustre is intermediate between vitreous and resinous. It has threefold cleavage, and the folia are sometimes curved. The fragments are indeterminate angular, sometimes inclining to rhomboidal. It is translucent on the edges, or opaque. Affords a grey-coloured streak. Brittle, and easily frangible. When rubbed, it emits a strongly fetid urinous smell. Specific gravity 2.653, 2.688, 2.703, *John.*

Chemical Characters.—When pounded and boiled in water, it gives out a hepatic odour, which continues but for a short time. The filtrated water possesses weak alkaline properties, and contains a small quantity of a muriatic and sulphuric salt. It does not appear to be affected by pure alkalies. It dissolves with effervescence in nitrous and muriatic acids, and leaves behind a coal-black or brownish-coloured residuum.

		From Stavern in Norway.
Constit. Parts.—	Carbonic acid	41.50
	Lime . .	53.37
	Oxide of manganese	0.75
	Oxide of Iron	1.25
	Oxide of carbon	1.25
	Sulphur . .	0.25
	Alumina .	1.25
	Silica . .	1.25
	Alkali, alkaline muriate, water, magnesia, zirconia .	2.13——100.00

John, Chem. Laborat. b. ii. s. 246.

Geognostic and Geographic Situations.—It occurs in balls, varying from the size of a pea to two feet in diameter, in brown dolomite, at Building Hill near Sunderland. At Stavern in Norway, it appears to occur in transition-rocks; in alum-slate at Garphytta in Nericke; in Greenland; and in the Russbachthal in Salzburg.

Third Kind.

Foliated or Sparry Lucullite, *Jameson.*—Späthiger Lucullan, *John.*

External Characters.—Colours yellowish, greyish, and greenish-white; also bluish-grey, and greyish and velvet black. Occurs massive, disseminated, in small granular concretions, and crystallized in acute six-sided pyramids. Internally alternates from glimmering to shining. Fragments generally rhomboidal. Translucent, or translucent on the edges. Semi-hard, approaching to soft. Brittle, and easily frangible. When rubbed, it emits an urinous smell. Specific gravity 2.650, *John.*

Chemical Characters.—They agree with those of the preceding subspecies: in its solution in acids there remains a minute black-coloured residuum.

Constituent Parts.

		From Moscau.
Carbonate of Lime,	- -	96.50
Carbonate of Manganese, Magnesia, and Iron,	- - -	1.50
Oxide of Iron,	- - -	1.00
Lime, Alumina, Carbon, Silica, & Water,		1.00—100.00

John, Chem. Laborat. b. iii. s. 90.

Geognostic and Geographic Situations.—It occurs in veins, and also in small cotemporaneous masses, in a bed of limestone in clay-slate, at Andreasberg in the Hartz; in veins of silver-ore in hornblende-slate at Kongsberg in Norway; also in transition alum-slate in larger and smaller elliptical masses, the centre of which is of iron-pyrites, and the periphery sparry lucullite, at Andrarum in Schonen, Garphytta in Nericke, and Christiania in Norway.

Eleventh Subspecies.

Marl, *Jameson.*—Mergel, *Werner.*

This subspecies is divided into two kinds, viz. Earthy Marl and Compact Marl.

First Kind.

Earthy Marl, *Jameson.*—Mergel Erde, *Werner.*

External Characters.—Colours yellowish-grey, and seldom pale smoke-grey. These are the colours it exhibits when dry: when moist, and in its original repository, its colours are pale blackish-brown or brownish-black.* Consists of fine dusty particles, either loose or

* Some of the varieties have generally a brown colour, and emit an urinous smell; these are by some authors considered as Earthy Stinkstone.

feebly cohering. Is dull. Particles feel fine, or rather rough and meagre. Soils slightly. Is light.

Chemical Characters.—It effervesces strongly with acids. It emits a strong urinous smell when first dug up; but after exposure to the air it loses this quality.

Constituent Parts.—It is said to be composed of lime, alumina, silica, and bitumen.—*Freiesleben.*

Geognostic and Geographic Situations.—It occurs in beds in flœtz or secondary limestone and gypsum formations, along with stinkstone, in Thuringia and Mansfeld.

Second Kind.

Compact or Indurated Marl, *Jameson.*—Verharteter Mergel, *Werner.*

External Characters.—Colours yellowish-grey, smoke-grey, and muddy bluish-grey. Sometimes spotted reddish and brownish in the rents, and marked with dendritic delineations. Occurs massive, in blunt angular pieces, vesicular, in flattened balls; and frequently contains petrifactions of fishes and crabs, also of gryphites, belemnites, chamites, pectinites, ammonites, terebratulites, ostracites, musculites, and mytulites. Dull both externally and internally, and only glimmering when intermixed with foreign parts. Fracture generally earthy, which approaches sometimes to splintery, sometimes to conchoidal; in the great inclines to thick and straight slaty. Fragments angular and blunt-edged, and sometimes tabular. Yields to the nail. Is opaque. Affords a greyish-white streak. Rather brittle, and easily frangible. Feels meagre. Specific gravity 2.365, 2.550, *Breithaupt.*

Chemical Characters.—Before the blow-pipe it intumesces, and melts into a greenish-black slag. It effervesces briskly with acids.

Const. Parts.—Carbonate of Lime,		50
	Silica,	12
	Alumina,	32
	Iron and Oxide of Manganese,	2—*Kirwan.*

Geognostic Situation.—It occurs in beds in the secondary flœtz limestone and coal formations; also in the new secondary formations that rest upon chalk.

Geographic Situation.—It frequently occurs in the coal formation in Scotland and England, and in the secondary formations which rest upon chalk in the south of England.

Uses.—Several different kinds of compact marl occur in nature: these are calcareous marl, in which the calcareous earth predominates; clay marl, in which the aluminous earth is in considerable quantity; and ferruginous marl, in which the mass contains a considerable intermixture of oxide of iron. The latter kind occurs in spheroidal concretions, called *septaria*, or *ludi Helmontii*, that vary from a few inches to a foot and a half in diameter. When broken in a longitudinal direction, we observe the interior of the mass intersected by a number of fissures, by which it is divided into more or less regular prisms, of from three to six or more sides, the fissures being sometimes empty, but oftener filled up with another substance, which is generally calcareous spar. From these septaria are manufactured that excellent material for building under water, known by the name of *Parker's Cement.** The calcareous and aluminous marl are used for improving particular kinds of land; also for mortar; in some kinds of pottery; and in the smelting of particular ores of iron.

Twelfth Subspecies.

Bituminous Marl-Slate, *Jameson.*—Bituminöser Mergelschiefer, *Werner.*

External Characters.—Colour intermediate between greyish-black and brownish-black. Occurs massive, and frequently contains impressions of fishes and plants. Lustre glimmering glistening, or shining, and resinous. Fracture straight, or curved slaty. Fragments slaty in the large, but indeterminate and rather sharp angular in the small. Is opaque. Shining and resinous in the streak. Soft, and feels meagre. Rather sectile, and easily frangible. Specific gravity, 2.631, 2.690, *Breithaupt.*

Constituent Parts.—It is said to be a carbonate of lime united with alumina, iron, and bitumen.

Geognostic Situation.—It occurs in secondary or flœtz limestone. It frequently contains cupreous minerals, particularly copper-pyrites, copper-glance, variegated copper-ore, and more rarely, native copper, copper green, and blue copper. It contains abundance of petrified fishes, and these are said to be most numerous in those situations where the strata are basin-shaped.

Geographic Situation.—*Europe.*—It abounds in the Hartzgebirge; also in Magdeburg and Thuringia. It is a frequent mineral in Upper and Lower Saxony: it occurs also in Franconia, Bohemia, Bavaria, Silesia, Suabia, Hesse-Cassel, and Switzerland.

America.—It is said to occur in the Cordilleras of South America.

III. Short-Axed Limestone, or Dolomite.—Kurzaxiges Kalk-Haloide, *Mohs.*

Rhomboid=107° 22′. Cleavage rhomboidal. Hardness=4.0,—4.5, sp. gr.=3.0,—3.2.

This species contains three subspecies, viz. 1. Dolomite; 2. Miemite; 3. Brown Spar.

First Subspecies

Dolomite, *Jameson.*

This subspecies is divided into three kinds, viz. Granular Dolomite, Columnar Dolomite, Compact Dolomite.

First Kind.

Granular Dolomite, *Jameson.*

This is again divided into White and Brown Granular Dolomite.

External Characters.—Colours snow-white, greyish-white, and rarely pale ash-grey. Occurs massive; also in small and fine granular distinct concretions, frequently so loosely aggregated, that they can be separated by mere pressure of the finger. Internally glimmering, approaching to glistening, and lustre pearly. Fracture in the large imperfect and slaty, in compact varieties small splintery, which passes into uneven. Fragments indeterminate angular, and blunt-edged. Faintly trans-

* These marly septaria abound in the Isle of Shepey, in the Medway, and often contain in their interior globular portions of heavy-spar, having diverging fibrous concretions. Similar septaria occur in Derbyshire, and in the county of Durham, in which latter district the internal fissures are filled with quartz.

lucent, or only translucent on the edges. Brittle, and easily frangible.

Chemical and Physical Characters.—It effervesces very feebly with acids,—a character which distinguishes it from granular limestone.

		St. Gothard.
Const. Parts.—	Carbonate of Magnesia,	46.50
	Carbonate of Lime, .	52 08
	Oxide of Manganese, .	0.25
	Oxide of Iron, . .	0.50
	Loss, ...	0.75—100

Klaproth, Beit. b. iv. s. 209.

	Iona.
Carbonic Acid, . .	48.00
Lime, ...	31.12
Magnesia, . . .	17.06
Insoluble Matter, . .	4.00

Tennant, Phil. Trans. for 1799.

Geognostic Situation.—It occurs principally in primitive mountains.

Geographic Situation.—*Europe.*—Beds of Dolomite, containing tremolite, occur in the island of Iona; and it is found in many countries on the Continent of Europe.

America.—Province of New-York, with tremolite.

Asia.—Bengal, with imbedded tremolite; also in Siberia.

Uses.—It appears to have been used by ancient sculptors in their finest works.

Observations.—It is named Dolomite, in honour of the celebrated French geologist, Dolomieu.

* Brown Dolomite, or Magnesian Limestone of Tennant.

Tennant, *Transactions of Royal Society of London for* 1799.—Thomson, *Annals of Philosophy for December*, 1814.

External Characters.—Colours yellowish-grey, yellowish-brown, and a colour intermediate between chesnut-brown and yellowish-brown; seldom bluish-grey. Occurs massive, and in minute granular concretions. Internally glistening or glimmering, and the lustre between pearly and vitreous. Fracture splintery, and sometimes flat conchoidal. Fragments indeterminate angular, and rather blunt-edged. Translucent, or translucent on the edges. Semihard; is harder than calcareous-spar. Is brittle. Specific gravity of the crystals, 2.823, *Tennant.*—2.777, 2.820, *Berger.*—2.791, *Thomson.*

Chemical Characters.—It dissolves slowly, and with but feeble effervescence, in nitrous acid.

		Building Hill, near Sunderland.
Const. Parts.—	Carbonate of Lime,	56.80
	Carbonate of Magnesia,	40.84
	Carbonate of Iron,	0.36
	Insoluble Matter, .	2.00—100.00

Thomson, *Annals of Phil.* vol. iv. p. 416.

Geognostic Situation.—In the north of England it occurs in beds of considerable thickness, and great extent, and appears to rest on the Newcastle coal-formation; but in the Isle of Man, it occurs in a limestone which rests on grey-wacke, and contains imbedded portions of quartz, rhomb-spar, and sparry-iron. It occurs in trap-rocks in Fifeshire.

Geographic Situation.—It occurs in Nottinghamshire, Derbyshire, Northamptonshire, Leicestershire, Northumberland, and Durham: also in Ireland, at Portumna in Galway, Ballyshannon in Donnegal, Castle Island, near Killarney.

Use.—Like common limestone, it is burnt and made into mortar, but it remains much longer caustic than quicklime from common limestone; and this is the cause of a very important difference between magnesian and common limestone, with regard to their employment in agriculture: Lime, from magnesian limestone, is termed *hot*, and when spread upon land in the same proportion as is generally practised with common quicklime, greatly impairs the fertility of the soil; and when used in a greater quantity, is said by Mr. Tennant to prevent all vegetation.

Observations.—A flexible variety of Dolomite occurs in England. The following account contains all the information we possess in regard to it:

Flexible Dolomite, *Jameson.*

External Characters.—Colour yellowish-grey, passing into cream-yellow. Occurs massive. Is dull. Fracture earthy in the small, and slaty in the large. Is opaque. Yields readily to the knife, but with difficulty to the nail. In thin plates it is uncommonly flexible. Specific gravity, 2.544, *Thomson.* This is probably below the truth, as the stone is porous.

Geographic Situation.—It occurs about three miles from Tinmouth Castle.

Observations.—This curious mineral was discovered by our intelligent friend Mr. Nicol, Lecturer on Natural Philosophy. To that gentleman we are indebted for the following particulars in regard to it. He finds, that its flexibility is considerably influenced by the quantity of water contained in it. When saturated with water, it is remarkably flexible; as the evaporation goes on, it becomes more and more rigid, until the water be reduced to a certain limit, when the flexibility becomes scarcely distinguishable. From this point, however, the flexibility gradually increases, as the moisture diminishes; and as soon as the water is completely exhaled, it becomes nearly as flexible as it was when saturated with that fluid.

Second Kind.

Columnar Dolomite.—Stänglicher Dolomit, *Klaproth.*

External Characters.—Colour pale greyish-white. Occurs massive, in thin, long, and straight prismatic concretions. Has an imperfect cleavage. Fracture uneven. Lustre vitreous, inclining to pearly. Breaks into acicular-shaped fragments. Feebly translucent. Is brittle.

		From the Mine Tschistagowskoy.
Const. Parts.—	Carbonate of Lime, .	51
	Carbonate of Magnesia, .	47
	Carbonated Hydrate of Iron,	1—99

Klaproth, Chem. Abhandl. s. 328.

Geognostic and Geographic Situations.—It occurs in serpentine in the mine Tschistagowskoy, on the river Mjafs, in the government of Orenberg in Russia.

Third Kind.

Compact Dolomite, or Gurhofite, *Jameson.*—Gurhofian, *Karsten.*

External Characters.—Colour snow-white. Occurs massive. Dull. Fracture flat conchoidal, passing to even. Fragments indeterminate angular, and sharp-edged. Slightly translucent on the edges. Hard, bordering on semihard. Brittle, and rather difficultly frangible.

Chemical Characters.—When pounded, and thrown into diluted and heated nitrous acid, it is completely dissolved, with effervescence.

Const. Parts.—	Carbonate of Lime,	70 50
	Carbonate of Magnesia,	29 50—100.00

Klaproth. Gesellsch. N. Fr. b. i. s. 258.

Geognostic and Geographic Situations.—It occurs in veins in serpentine rocks, between Gurrhof and Aggsbach, in Lower Austria.

Second Subspecies.

Miemite, *Jameson* and *Klaproth.*

This subspecies is divided into two kinds, viz. Granular Miemite, and Prismatic Miemite.

First Kind.

Granular Miemite.

External Characters.—Colour pale asparagus-green, which passes into greenish-white. Occurs massive, in large and coarse angulo-granular distinct concretions; crystallized in flat double three-sided pyramids, in which the lateral planes of the one are set on the lateral edges of the other. Crystals middle-sized, or small; either attached by their lateral edges, or intersecting each other; surface drusy. Internally splendent and pearly. Fragments rather blunt-edged. Translucent. Semihard. Brittle. Specific gravity 2.885.

Const. Parts.—	Carbonate of Lime, . .	53.00
	Carbonate of Magnesia, .	42.50
	Carbonate of Iron, with a little Manganese, . .	3.00
		98 50

Klaproth, Beit. b. iii. 296.

Geognostic and Geographic Situations.—It is found at Miemo in Tuscany, imbedded in gypsum.

Observations.—This mineral was first observed by the late Dr. Thomson of Naples, who sent specimens of it to Klaproth for analysis. It is named *Miemite*, after the place where it was discovered.

Second Kind.

Prismatic Miemite, *Jameson.*—Stänglicher Bitterspath, *Klaproth.*

External Characters.—Colour asparagus-green, olive-green, and oil-green. Occurs in prismatic distinct concretions, and crystallized in flat rhomboids, which are deeply truncated on all the edges. Crystals small, and very small, and sometimes they form only drusy crusts. Internally shining and vitreous. Fracture passes from concealed foliated to splintery. Fragments rather blunt-edged. Strongly translucent. As hard as the granular miemite. Specific gravity, 2.885, *Karsten.*

Chemical Characters.—It dissolves slowly, and with but feeble effervescence, in nitrous acid.

Constituent Parts.—	Lime, ...	33.00
	Magnesia, . . .	14.50
	Oxide of Iron, . .	2.50
	Carbonic Acid, . .	47.25
	Water and Loss, .	2.75—100

Klaproth, Beit. b. iii. s. 303.

Geognostic and Geographic Situations.—It occurs in cobalt veins that traverse sandstone at Glücksbrunn in Gotha, and at Beska in Servia, on the frontier of Turkey.

Third Subspecies.

Brown-Spar, or Pearl-Spar, *Jameson.* Braunspath, *Werner.*

This species is divided into two kinds, viz. Foliated Brown-Spar, and Columnar Brown-Spar.

First Kind.

Foliated Brown-Spar, *Jameson.*—Blättriger Braunspath, *Werner.*

External Characters.—Colours flesh-red and brownish-red. Often occurs massive, also disseminated, seldom globular, stalactitic, reniform, with tabular and pyramidal impressions; also in distinct concretions, which are granular, and rarely thin and straight lamellar; and frequently crystallized. Surface of the crystals usually drusy, and seldom shining, generally glistening or glimmering, and sometimes even dull. Internally alternates from shining to glistening, very rarely splendent, and lustre pearly. Fragments indeterminate angular, and rather blunt-edged in the great, but in the small are rhomboidal. Generally translucent on the edges, rarely translucent. Brittle, and easily frangible. Specific gravity 3.0, 3.2, *Mohs.*

Chemical Characters.—It hardens, and becomes dark brownish-black before the blowpipe; and effervesces feebly with acids.

Constituent Parts.—	Lime, ...	43.0
	Magnesia, ...	10.0
	Oxide of Iron, ...	8.0
	Manganese, ...	3.0
	Water, and Carbonic Acid,	26.5

Berthier, Journ. des Mines, No. 103. p. 73.

Geographic Situation.—It occurs along with galena, and other ores of lead, in the lead mines of Lead Hills and Wanlockhead in Lanarkshire; in the mines of Cumberland, Northumberland, and Derbyshire.

Second Kind.

Columnar Brown-Spar, *Jameson.* Stänglicher Braunspath, *Klaproth.*

External Characters.—Colours reddish-white, rose-red, and pearl-grey. Occurs in distinct concretions, which are wedge-shaped columnar or prismatic, and have glimmering and longitudinally streaked surfaces. Splendent, and appears pearly on the fracture surface. Has an imperfect cleavage. Fragments wedge-shaped. Translucent. Brittle. Easily frangible.

Constit. Parts.—	Carbonate of Lime, . .	51.50
	Carbonate of Magnesia,	32.00
	Carbonate of Iron, . .	7 50
	Carbonate of Manganese,	2 00
	Water, ...	5.00
		98.00

Klaproth, Beit. b. iv. s. 203.

Geographic Situation.—It is found at the mine named Segen Gottes at Gersdorf in Saxony; and in that of Valenciana at Guanauxuato in Mexico.

IV. Rhomb-spar, *Jameson.* Langaxiges Kalk-Haloid, *Mohs.*

Rhomboid=106° 16′. Cleavage rhomboidal. Hardness=3.5—4.0. Sp. gravity=2.8, 3.2.

External Characters.—Colours white, grey, and yellow. Occurs massive and disseminated; and crystallized in rhomboids, in which the obtuse angle is 106° 15′. These rhomboids are sometimes rounded or truncated on the edges. Crystals middle-sized and small; the surface is sometimes smooth, sometimes rough, and either shining or glimmering. Internally the lustre is splendent, between vitreous and pearly. Fracture imperfect conchoidal. Fragments rhomboidal. Easily frangible and brittle.

Chemical Characters.—Before the blowpipe it is infusible, without addition; even when pounded it effervesces but feebly; and dissolves slowly in muriatic acid.

Constit. Parts.—Carbonate of Lime, . 56.60
Carbonate of Magnesia, 42.00—98.60

Or by another result; Carbonate of Lime, 56.2
Carbonate of Magnesia, 43.5—98.9
With a trace of Manganese and Iron, *Murray.**

Geognostic Situation.—It occurs imbedded in chlorite-slate, talc-slate, limestone, and serpentine; in the salt formation, where it is imbedded in anhydrite and gypsum; in drusy cavities in compact dolomite, and in metalliferous veins.

Geographic Situation.—It occurs imbedded in chlorite-slate on the banks of Loch Lomond; in a vein in transition rocks, along with galena, blende, copper-pyrites, and calcareous-spar, near Newton-Stewart in Galloway; in compact dolomite in the Isle of Man and the north of England.

Order II. BARYTE.

No metallic lustre. Colour rarely changed in the streak; if orange-yellow, the specific gravity is 6, and more. Hardness ranges from 2.5. to 5. Sp. gravity ranges from 3.3 to 7.2. If the specific gravity be less than 3.6, and the hardness 5, the cleavage is di-prismatic.

Genus I.—RED MANGANESE.

One axis. Cleavage rhomboidal. Hardness=3.5, 4.5. Sp. gr.=3.3, 3.9.

This genus contains one species, viz. Rhomboidal Red Manganese.

1. Rhomboidal Red Manganese, *Jameson.*—Langaxiger Flintz-Baryt, *Mohs.*

Rhomboid= . Cleavage rhomboidal. Hardness =3.5. Sp. gravity=3.3, 3.6.

This species is divided into three subspecies, viz. 1. Foliated rhomboidal red manganese, 2. Fibrous rhomboidal red manganese, and 3. Compact rhomboidal red manganese.

First Subspecies.

Foliated Rhomboidal Red Manganese, *Jameson.*

External Characters.—Colour bright rose-red, slightly inclining to flesh-red. Occurs massive, disseminated, small reniform, globular, with tabular and rhomboidal impressions, and in granular distinct concretions. Internally shining, inclining sometimes to glistening, sometimes to splendent, and the lustre pearly. Fragments indeterminate angular, and rather sharp-edged, or rhomboidal. Generally translucent on the edges; in some rare varieties translucent. Brittle, and rather easily frangible.

Chemical Character.—Before the blowpipe, without addition, it first becomes dark brown, and then melts into a dark reddish-brown bead.

Const. Parts.—Oxide of Manganese,	.	52 60
Silica,	. . . .	39.60
Oxide of Iron,	. . .	4.60
Lime,	. . . .	1.50
Volatile ingredients,	.	2.75—101.5

Berzelius, in Afh. i. Fys. och. Min. i. 110.

Geognostic and Geographic Situations.—It occurs in beds of specular iron-ore and magnetic iron-ore, along with compact garnet and calcareous-spar, in the gneiss hills at Langbanshytta, in Wermeland in Sweden; also at Catharinenburg in Siberia, and in Saxony.

Uses.—The Siberian varieties are cut and polished, and worn as ornamental stones.

Second Subspecies.

Fibrous Rhomboidal Red Manganese, *Jameson.*

External Characters.—Colours rose-red andflesh-red, inclining to grey and brown. Occurs massive, and in prismatic fibrous concretions, which are straight, scopiform and stellular. Internally glistening and pearly. Fragments splintery and wedge-shaped. Feebly translucent.

Geognostic and Geographic Situations.—It occurs in veins in primitive and transition rocks. It is a rare mineral, and is principally found at Kapnik in Transylvania, and at Schemnitz in Hungary.

Third Subspecies.

Compact Rhomboidal Red Manganese, *Jameson.*

External Characters.—Its principal colour is pale rose-red, which sometimes passes into dark reddish-white. Occurs massive, disseminated, and sometimes imperfectly reniform. Internally dull or glimmering. Fracture even sometimes inclining to splintery. Fragments indeterminate angular, and rather sharp-edged. Brittle, and easily frangible.

Chemical Characters.—It is infusible before the blowpipe, but becomes black by ignition.

		Siberia.
Constituent Parts.—Oxide of Manganese,	.	61
Silica,	. . . .	30
Oxide of Iron,	. . .	5
Alumina,	. . . . .	2—98

Lampadius, in Pract. Chem. Abh. b. ii. s. 209.

Geognostic and Geographic Situations.—It occurs at Kapnik in Transylvania; at Langbanshytta, in Wermeland in Sweden; and Catharinenburg in Siberia.

* The above analysis was communicated to us by the late Dr. Murray.

Genus II.—SPARRY IRON.

Kurzaxiger Flinz Baryt, *Mohs.*—Spathisenstein, *Werner.* Fer oxydé carbonatée, *Haüy.*

One axis. Cleavage rhomboidal. Hardness = 3.5, 4.6. Sp. gr. = 3.6, 3.9.

This genus contains one species, viz. Common Sparry iron.

1. Common Sparry Iron, *Jameson* —Spatheisenstein, *Werner.* Fer oxydé carbonatée, *Haüy.*

Rhomboid=107°. The most perfect cleavage is in the direction of the planes of the primitive rhomboid ; the least perfect in the direction of the planes of a flat rhomboid. Hardness=3.5, 4.5. Spec. gravity = 3.6, 3.9.

External Characters.—Colours yellow, white, brown, and black. Occurs massive, disseminated, with pyramidal impressions ; also in granular distinct concretions ; and crystallized. The following are some of its principal crystallizations :

1. Primitive rhomboid.
   a. Perfect, with straight or spherical convex lateral faces.
   b. Truncated on the apices.
   c. Truncated on the terminal edges.
   d. Rounded off on the apices and edges.
   When the truncating planes in the variety 1. *c.* become so large that the original planes disappear, there is formed
2. A still flatter rhomboid.
   From the variety 1. *d.* there arises
3. The spherical lenticular form.
   From the rhomboid with curved faces there is formed
4. The saddle-shaped lens.
   We sometimes observe the primitive form arranged in rows, so as to form an
5. Equiangular six-sided prism, flatly acuminated with three planes, which are set on the alternate lateral planes.

Crystals middle-sized, small, and very small. Seldom singly superimposed, as is the case with the lens, most generally aggregated in druses. Planes of the lens delicate drusy, but all of the other forms generally smooth ; and the lustre varies from splendent, through shining, to glistening. Internally generally glistening, sometimes inclining to shining, and even to splendent; but the black variety is only glimmering, and the lustre is pearly. The imperfect foliated fracture is sometimes conjoined with the splintery ; and this occurs principally in the greenish-grey varieties. Fragments rhomboidal in the foliated varieties, but rather sharp-edged in the compact. Generally translucent on the edges, also translucent ; but the black varieties are opaque. The pale varieties afford a white, the darker varieties a yellowish-brown streak. It is not particularly brittle, and is easily frangible.

Chemical Characters.—It blackens, and becomes magnetic before the blowpipe, but does not melt : it effervesces with muriatic acid. It dissolves with ebullition in glass of borax, and communicates to it an olive-green colour.

Constituent Parts.		Steinhem.
	Oxide of iron .	63.75
	Carbonic acid .	34.00
	Oxide of manganese	0.75
	Magnesia . .	0.25
	Loss . .	1.25—100.00

Klaproth, in Magaz. Natf. Fr. b. v. s. 335.

Geognostic Situation.—It occurs in veins in granite, gneiss, mica-slate, clay-slate, and grey-wacke, and in these it is associated with ores of lead, cobalt, silver, and seldomer with nickel and bismuth ; more frequently with galena, grey copper ore, iron-pyrites, and grey antimony ore. In other veins it is accompanied with brown, red, and black iron ore, calcareous-spar, and quartz. But the most extensive formations of this mineral are in limestone, by some referred to primitive, by others to secondary rocks, in which it is arranged in thick beds. It also occurs filling up amygdaloidal cavities in trap rocks.

Geographic Situation.—Europe.—It occurs in small quantities in different places in England, Scotland, and Ireland ; but very abundant in Hessia, Carinthia, and other countries on the continent of Europe.

Uses —It affords an iron which is excellently suited for steel making. The black variety is said to afford the best kind of iron.

Genus III. CALAMINE.*

Zink-Baryt, *Mohs.*

One and three axes. Cleavage di-prismatic ; rhomboidal. If rhomboidal, = 4.2 and more. Hardness = 5.0 sp. gr. = 3 3,—4.5.

This genus contains two species, viz. 1. Prismatic Calamine; and. 2. Rhomboidal Calamine.

1. Prismatic Calamine, or Electric Calamine, *Jameson* —Prismatischer Zink-Baryt, *Mohs.* Zinc Oxydé, *Haüy.*

Vertical prism = 99° 56′. Horizontal prism, in the direction of the longest diagonal, = 120°. Cleavage the same. Hardness = 5.0. Sp. gr. = 3.3, 3.6.

External Characters.—Most common colours white and yellow ; it also occurs green, grey, yellow, and brown. Has sometimes a curved striped colour delineation. Occurs massive, disseminated, in crusts, stalactitic, reniform, botryoidal, cellular, corroded ; also in distinct concretions, which are scopiform, radiated, or fibrous, granular, and curved lamellar. Sometimes crystallized. The following are some of its secondary forms : 1. Six-sided prism. 2. Flat six-sided prism, bevelled on the terminal planes ; the bevelling planes set on the broader lateral planes. This prism is sometimes so flat, that it appears like a longish rectangular four-sided table bevelled on the terminal planes. 3. Acute double four-sided pyramid, sometimes perfect, sometimes truncated on the summits. 4. Acute double four-sided pyramid, acuminated on both extremities, with four planes, which are set on the lateral planes, and sometimes the summits are truncated.

Crystals small ; either solitary or scopiformly aggregated. Internally, the lustre alternates from glistening to dull, and lustre pearly, inclining to adamantine. Fracture small and fine grained uneven. Alternates from transparent to translucent on the edges, and opaque.

* Agricola says, that because the cadmia (calamine) in the furnace attaches itself to the iron bars in forms like a reed, (calamus) it was named *Calamine.*

Crystallized varieties as hard as apatite; the massive and opaque softer. Dark-coloured varieties afford a yellowish grey streak.

Physical Characters.—When gently heated, it is strongly electric.

Chemical Characters.—It loses, according to Pelletier, about 12 *per cent.* by ignition; it is soluble in muriatic acid without effervescence; and the solution gelatinises on cooling.

		Rezbanya.
Constituent Parts.—	Oxide of Zinc,	68.30
	Silica, - -	25.00
	Water, - -	4 40—97.70

Smithson, in Phil. Trans. Part i. for 1803.

Geognostic Situation.—It occurs in small quantities in metalliferous veins, principally along with ores of lead, in grey-wacke, grey-wacke-slate, and clay-slate; but most frequently in secondary or floetz limestone, in imbedded masses, and irregular beds.

Geographic Situation.—It occurs in the lead-mines at Wanlockhead; also in Leicestershire and Flintshire, and in several countries on the Continents of Europe and Asia.

2. Rhomboidal Calamine, *Jameson.*—Galmei, *Werner.* Rhomboedrischer Zink-Baryt, *Mohs.*

Rhomboid about 110°. Cleavage in the direction of the planes of the rhomboid. Hardness = 5.0. Sp. gr. = 4.2, 4.4.

This species is divided into three subspecies, viz. Sparry Rhomboidal Calamine, Compact Rhomboidal Calamine, and Earthy Rhomboidal Calamine.

First Subspecies.

Sparry Rhomboidal Calamine, *Jameson.*—Spathiger Galmei, *Karsten.*

External Characters.—Colours white, grey, green, and brown. Occurs massive, botryoidal, reniform, stalactitic, tabular, cellular; also in distinct concretions, which are prismatic, granular, and curved lamellar; and sometimes crystallized. Internally shining and pearly. Fragments rhomboidal. Alternates from semitransparent to opaque.

Chemical Characters.—It dissolves with effervescence in muriatic acid; it is infusible; loses about 34 *per cent.* by ignition.

Constituent Parts.

	Derbyshire.	Somersetshire.
Oxide of Zinc, -	65.2	64.8
Carbonic Acid, -	34.8—100	35.2—100

Smithson, in Phil. Trans. Part i. for 1803.

Second Subspecies.

Compact Rhomboidal Calamine, *Jameson.*—Gemeiner Galmei, *Karsten.*

External Characters.—Colours grey, yellow, and yellowish-brown. Occurs massive, disseminated, corroded, reniform, stalactitic, and cellular; also in concentric curved lamellar concretions. Rarely in supposititious crystals, or incrusting other crystals. Internally dull, or very feebly glimmering and resinous. Fracture coarse-grained uneven, fine splintery, even, and flat conchoidal. Opaque, or feebly translucent on the edges.

Chemical Characters.—The same as in the preceding subspecies.

Third Subspecies.

Earthy Rhomboidal Calamine, *Jameson.*—Zinkbluthe, *Karsten.*

External Characters.—Colour white, sometimes with a yellowish-brownish exterior. Occurs massive, disseminated, botryoidal, flat, reniform, and with impressions. Internally dull. Fracture fine earthy. Opaque. Yields to the nail. Adheres to the tongue.

Chemical Characters.—The same as in the first subspecies.

		Bleiberg in Carinthia.
Constituent Parts.—	Oxide of Zinc,	71.4
	Carbonic Acid,	13.5
	Water, ..	15.1—100.0

Smithson, in Phil. Trans. Part I. for 1803.

Geognostic Situation of the Species.—It occurs in beds, nests, filling up or lining hollows, in transition limestone, and in secondary or floetz limestone, and conglomerate rock; also in veins.

Geographic Situation of the Species.—*Europe.*—It occurs in the Mendip Hills, at Shipham, near Cross, Somersetshire; at Alionhead in Durham; at Holywell, and elsewhere in Flintshire; and in Derbyshire.

Uses.—Both prismatic and rhomboidal calamine, when purified and roasted, are used for the fabrication of brass, which is a compound of zinc and copper; and the pure metal is also employed for a variety of other purposes.

Genus IV. TUNGSTEN,* or SCHEELIUM.†

Scheel Baryt, *Mohs.*

One axis. Cleavage pyramidal. Hardness = 4.0—4.5. Sp. gr. = 6.0—6.1.

This genus contains one species, viz. Pyramidal Tungsten.

1. Pyramidal Tungsten, *Jameson.*—Pyramidaler Scheel-Baryt, *Mohs.* Schwerstein, *Werner.*

Pyramid = 107° 26′—113° 36′. The most distinct cleavage is that parallel with the planes of the primitive pyramid; another, less distinct, in which the planes are parallel with the sides of an acute pyramid, (100° 8′; 130° 20′;) and a third, the least distinct, parallel with the common base of the pyramid.

External Characters.—White is the principal colour of this mineral. The following varieties of colour also sometimes occur, viz. brown, which sometimes inclines to orange-yellow and hyacinth-red. Occurs massive, disseminated, also in distinct concretions, which are granular, seldomer wedge-shaped prismatic, and these latter traversed by others which are curved lamellar. Sometimes crystallized. The following are the secondary forms:

1. The primitive figure, in which the angles of the common base are flatly bevelled, and the bevelling planes set on the lateral edges. 2. Very acute double four-sided pyramid, in which the lateral planes of the one are set on the lateral planes of the other. 3. Flat double four-sided pyramid.

Crystals middle-sized, small and very small; they are always superimposed, sometimes in single crystals, sometimes in druses. Lateral planes of the crystals

* The name *Tungsten* was given to this mineral by the Swedes, on account of its great weight.

† Werner gave the name *Scheele* to this genus, in honour of the illustrious chemist Scheele, who discovered the peculiar metal which characterises it.

generally smooth; planes of the first pyramids slightly streaked; shining and splendent; lustre inclines to adamantine. Internally shining, lustre resinous, sometimes inclining to adamantine. Fracture coarse, or small-grained uneven, passing into imperfect conchoidal. Fragments indeterminate angular, rather blunt-edged. More or less translucent, seldom semitransparent. Rather brittle, easily frangible.

Chemical Characters.—It crackles before the blowpipe and becomes opaque, but does not melt; with borax it forms a transparent or opaque white glass, according to the proportions of each.

		Cornwall.
Constit. Parts.—	Oxide of Tungsten	75.25
	Lime, . .	18.70
	Silica, . .	1.56
	Oxide of Iron, .	1.25
	Oxide of Manganese,	0.75—97.45

Geognostic Situation.—It occurs along with tinstone, magnetic iron-ore, and brown iron-ore, in primitive rocks.

Geographic Situation.—It occurs along with wolfram and tin-ore at Pengilly in Breage in Cornwall; at Bispberg in Sweden, in a bed of magnetic iron-ore.

Genus V. BARYTE.

One and three axes. Cleavage rhomboidal and prismatic. If cleavage rhomboidal, specific gravity =4.2 and more. Hardness =3.0, —3.5. Sp. gravity =3.6 —4.6.

1. Di-Prismatic Baryte, or Strontianite, *Jameson.*—Diprismatischer Hal-Baryt, *Mohs.* Strontian, *Werner.*

Vertical prism =117° 19′. Horizontal prism in the direction of the smaller diagonal. Cleavage in the direction of the planes of both prisms. Hardness =3.5. Sp. gravity =3.6—3.8.

External Characters.—Colour pale asparagus-green, which sometimes inclines to apple-green, sometimes to yellowish-white and greenish-grey. The greenish-grey variety sometimes passes into milk and yellowish-white, and pale straw-yellow. Occurs massive, in distinct concretions, which are scopiform, radiated and fibrous, and crystallized. The primitive form is an oblique four-sided prism, bevelled on the extremities. Its secondary figures are the following: 1. Acicular six-sided prism, acutely acuminated with six planes, which are set on the lateral planes. 2. Acicular acute double six-sided pyramid. Crystals are sometimes scopiformly and manipularly aggregated. Lustre of the distinct concretions shining or glistening; the fracture glistening, and pearly. Fracture fine-grained uneven. Fragments wedge-shaped or splintery. More or less translucent, and sometimes semi-transparent. Brittle, and easily frangible.

Chemical Characters.—Is fusible before the blowpipe, but becomes white and opaque, and tinges the flame of a dark purple colour. Is soluble, with effervescence, in muriatic or nitric acid; and paper dipped in the solutions thus produced burns with a purple flame.

Constituent Parts.—	Strontian, .	61.21
	Carbonic Acid,	30 20
	Water, .	8.50—100.00

Hope, Edin. Trans. for 1790.

Geognostic and Geographic Situations.—It occurs at Strontian in Argyleshire, in veins that traverse gneiss, along with galena or lead-glance, heavy-spar, and calcareous-spar.

2. Rhomboidal Baryte, or Witherite, *Jameson.* Rhomboedrischer Hal-Baryt, *Mohs.* Witherit, *Werner.*

Rhomboid =91° 54′. The most distinct cleavage is that parallel with the planes of the rhomboid, and another, less distinct, parallel with the alternate planes of the six-sided pyramid. Hardness =3.0, 3.3. Sp. gr. =4.2, 4.4.

External Characters.—Colours white, grey, and yellow. Occurs massive, disseminated, in crusts, cellular, corroded, large globular, reniform, botryoidal, stalactitic; also in distinct concretions, which are wedge-shaped, sometimes scopiform radiated, and occasionally pass into coarse granular. More rarely crystallized. The following are the secondary forms:

1. Equiangular six-sided prism.
   a. Truncated on the terminal edges.
   b. Acutely acuminated on the extremities with six planes, which are set on the lateral planes.
2. Acute double six-sided pyramid, in which the lateral planes of the one are set on the lateral planes of the other.

The crystals are small, and very small, seldom middle-sized. The prisms are sometimes scopiformly grouped, or they are in druses. Externally glistening; internally shining on the cleavage, and glistening on the fracture, and the lustre is resinous. Principal fracture uneven, inclining to splintery. Fragments wedge-shaped, or indeterminate angular. Translucent, rarely semi-transparent. Brittle, and easily frangible.

Chemical Characters.—Before the blowpipe it decrepitates slightly, and melts readily into a white enamel; it is soluble, with effervescence, in diluted muriatic or nitric acid.

Constit. Parts.—	Carbonate of Barytes	96.3
	Carbonate of Strontian	1.1
	Sulphate of Barytes	0.9
	Silex . . .	0.5
	Alumina, and Oxide of Iron . .	6.25—99.05

Aikin, Gol. Tr. v. iv. part ii. p. 442.

Geognostic and Geographic Situations.—It occurs in Cumberland and Durham, in lead veins that traverse a secondary limestone, which rests on red sandstone, and in these it is associated with coralloidal arragonite, brown spar, earthy fluor spar, heavy spar, and galena or lead-glance, white lead spar, green lead spar, copper-pyrites, blue copper, malachite, iron-pyrites, sparry iron, calamine, and blende.

Uses.—It is a very active poison, and in some districts, as in Cumberland, it is employed for the purpose of destroying rats. When dissolved by muriatic acid, the solution thus obtained is said to prove serviceable in scrofula.

3. Prismatic Baryte, or heavy spar, *Jameson.* Prismatischer Hal-Baryt, *Mohs.* Schwerspath, *Werner.*

Prism =101° 55′. The most distinct cleavage is that parallel with the terminal planes of the oblique four-sided prism; less perfect are those parallel with the lateral planes of the prism. Hardness =3.0, 3.5. Sp. gravity =4.1, 4.6.

This species is divided into nine subspecies, viz. 1. Earthy Heavy spar, 2. Compact Heavy spar, 3. Granular Heavy spar, 4. Curved Lamellar Heavy spar, 5. Straight Lamellar Heavy spar, 6. Fibrous Heavy spar,

7. Radiated Heavy spar, 8. Columnar Heavy spar, and 9. Prismatic Heavy spar.

First Subspecies.

Earthy heavy spar, *Jameson*. Schwerspath Erde, *Werner*.

External Characters.—Colours yellowish and reddish white. Of friable consistence, and consists of feebly glimmering, nearly dull, particles, which are intermediate between scaly and dusty, soils feebly, and are generally loose, or but feebly cohering. Feels meagre, and rather rough. Specific gravity, 4.0.

Constituent Parts.—It is sulphate of Barytes.

Geognostic and Geographic Situations.—It occurs in drusy cavities in veins of heavy spar, in Staffordshire and Derbyshire; at Freyberg in Saxony; Rieglesdorf in Hessia; and Mies in Bohemia.

Second Subspecies.

Compact heavy spar, *Jameson*. Dichter Schwerspath, *Werner*.

External Characters.—Colours white and grey. Occurs massive, disseminated, reniform, semi-globular, tuberose, with cubic impressions; and in curved lamellar concretions. Internally glimmering. Fracture intermediate between coarse earthy and fine grained uneven, which sometimes passes into imperfect foliated, and more rarely into splintery. Fragments indeterminate angular, and blunt-edged. Opaque or translucent on the edges. Rather sectile, and easily frangible. Sp. gravity, 4.84.

Geognostic and Geographic Situations.—It is found in the mines of Staffordshire and Derbyshire, where it is named *Cawk*.

Third Subspecies.

Granular Heavy Spar, *Jameson*.——Körniger Schwerspath, *Werner*.

External Characters.—Colours white, and sometimes ash-grey. Occasionally spotted brown and yellow on the surface. Occurs massive, and in fine granular concretions, which are sometimes so minute as scarcely to be discernable. Internally glistening, approaching to shining, and pearly. Fragments indeterminate angular, and blunt-edged. Feebly translucent. Soft. Rather brittle, and easibly frangible. Specific gravity, 4.300, *Klaproth*.

Constituent Parts.—Sulphate of Barytes,		90
Silica,	. .	10—100

Geognostic Situation.—Occurs principally in beds, along with galena, blende, copper-pyrites, and iron-pyrites.

Geographic Situation.—It occurs in beds, along with galena, blende, copper-pyrites, and iron-pyrites, at Peggau in Stiria; also in the Hartz, in beds, along with copper and iron pyrites, galena, and blende.

Fourth Subspecies.

Curved Lamellar Heavy-Spar, *Jameson*.——Krummschaaliger Schwerspath, *Werner*.

External Characters.—Principal colours white, grey, and red. Sometimes several colours occur together, and arranged in broad stripes. Generally occurs massive, more frequently reniform, and long globular, with a drusy surface; the drusy surface is formed of very small, thin, and longish four-sided tables; also in reniform curved lamellar concretions, which are frequently floriform, and these are again composed of prismatic concretions. It is rarely marked with cubical impressions. Internally intermediate between shining and glistening, and the lustre pearly, inclining to resinous. Fracture curved foliated, which sometimes inclines to splintery, and thus approaches to the compact subspecies. Fragments indeterminate angular, and rather blunt-edged. Translucent on the edges. Brittle, and easily frangible. Specific gravity, 4.307, *Breithaupt*.

Geognostic and Geographic Situations.—It is one of the most common subspecies of heavy-spar. In Scotland, it occurs in trap and sandstone rocks: in Derbyshire, it occurs in secondary limestone: it characterises a particular venigenous formation at Freyberg in Saxony, where it is associated with radiated pyrites, argentiferous galena, brown blende, calcareous-spar, and fluor-spar. It occurs in Sweden, Carinthia, and other countries.

Fifth Subspecies.

Straight Lamellar Heavy-Spar.

It is divided into three kinds, viz. Fresh Straight Lamellar Heavy-Spar, Disintegrated Straight Lamellar Heavy-Spar, and Fetid Straight Lamellar Heavy-Spar.

First Kind.

Fresh Straight Lamellar Heavy-Spar, *Jameson*.—Geradschaaliger Schwerspath, *Werner*.

External Characters.—Colours white, grey, black, blue, green, yellow, red, and brown. Occurs generally massive; also in distinct concretions, which are straight and thin lamellar; and again collected into others which are coarse granular; and also crystallized. The following are the secondary figures it exhibits:

1. Rectangular four-sided table. 2. Oblique four-sided table. 3. Longish six-sided table. 4. Eight-sided table.

Crystals vary in size, from large to small; and rest on one another, or intersect one another. Externally they are smooth and splendent; internally shining and splendent, and the lustre intermediate between resinous and pearly. Fragments tabular and rhomboidal. Translucent, or transparent, and refracts double. Brittle, and easily frangible.

Chemical Characters.—It decrepitates briskly before the blowpipe, and, by continuance of the heat, melts into a hard white enamel.

Constituent Parts.—Sulphate of Barytes,		97.60
	Sulphate of Strontian,	0.85
	Water, . . .	0.10
	Oxide of Iron, . .	0.80
	Alumina, . .	0.05

Klaproth, Beit, b. ii. s. 78.

Geognostic Situation.—It is found almost always in veins, which occur in granite, gneiss, mica-slate, clay-slate, greywacke, limestone, and sandstone. It is often accompanied with ores, particularly the flesh-red variety, and these are, native silver, silver-glance or sulphuretted silver, copper-pyrites, lead glance, white cobalt-ore, light red-silver, native arsenic, earthy cobalt, cobalt-bloom or red cobalt, antimony, and manganese. It occurs sometimes in beds, and encrusting the walls of drusy cavities.

Geographic Situation.—In this island, it occurs in veins in different primitive and transition rocks, and also in secondary limestone, sandstone, and trap. Beautiful crystallized varieties are found in the lead mines of Cumberland, Durham, and Westmoreland.

Second Kind.

DISINTEGRATED STRAIGHT LAMELLAR HEAVY-SPAR, *Jameson.*—Mulmicher oder murber geradschaaliger.—Schwerspath, *Werner.*

External Characters.—Colour white. Occurs massive. Glistening and pearly. Opaque, or faintly translucent on the edges. Very easily frangible. Other characters same as the preceding.

Geognostic and Geographic Situations.—It was formerly met with in considerable quantity at Freyberg in Saxony, in a mixture of galena, blende, and iron-pyrites.

Third Kind.

FETID STRAIGHT LAMELLAR HEAVY-SPAR, or HEPATITE, *Jameson.*

External Characters.—Colours white, grey, and black. Occurs massive, disseminated, and in globular or elliptical pieces, from an inch to a foot and upwards in diameter; also in lamellar concretions, which are generally straight, sometimes curved and floriform; sometimes there is a tendency to wedge-shaped and radiated concretions. Externally feebly glimmering; internally shining, and intermediate between pearly and resinous. Fragments indeterminate angular, and blunt-edged. Opaque, or translucent on the edges. Nearly as hard as straight lamellar heavy-spar. Affords a greyish-white coloured streak.

Chemical Characters.—It burns white before the blowpipe; and when rubbed or heated, gives out a fetid sulphureous odour.

Constituent Parts.—	Sulphate of Barytes,	85.25
	Carbon . .	0.50
	Sulphate of Lime,	6.00
	Oxide of Iron, .	5.00
	Alumina, . .	1.00
	Loss, including Moisture and Sulphur, .	2.25
		100.00

Klaproth, Beit. b. v. s. 121.

Geognostic and Geographic Situations.—It occurs at Buxton in Derbyshire; at Kongsberg, and Andrarum in Norway.

SIXTH SUBSPECIES.

FIBROUS HEAVY-SPAR, *Jameson.*—Fasriger Schwerspath, *Werner.*

External Characters.—Colour pale-yellowish, and wood-brown, which sometimes passes into yellowish-grey. Occurs massive and reniform; also in distinct concretions, which are scopiform prismatic or fibrous, sometimes collected into others, which are curved lamellar, and sometimes into coarse angulo-granular concretions. Internally shining, and lustre resinous. Fragments splintery, and wedge-shaped. Translucent on the edges.

Specific gravity, 4.080, *Klaproth.*—4.239, *Noeggerath.*

Constit. Parts.—	Sulphate of Barytes,	99.0
	Trace of Iron,	—99.0

Klaproth. Beit. b. iii. s. 288.

Geognostic and Geographic Situations.—Found at Neu-Leiningen in the Palatinate; also in an ironstone mine in clay-slate, at Chaud-Fontaine, near Luttich, in the Ourthe department; and at Mies in Bohemia.

SEVENTH SUBSPECIES.

RADIATED HEAVY-SPAR, or BOLOGNESE SPAR, *Jameson.*—Bologneser Spath, *Werner.*

External Characters.—Principal colour smoke-grey, which passes into ash-grey and yellowish-grey. Occurs in roundish pieces, which have a lenticular aspect and uneven surface; also in distinct concretions, which are parallel and scopiform prismatic, and also granular. Internally shining or glistening, and the lustre pearly, inclining to resinous. Fragments splintery, or wedge-shaped. Translucent. In other characters it agrees with the preceding.

Geognostic and Geographic Situations.—It occurs imbedded in marl in Monte Paterno, near Bologna: also at Rimini; and in Jutland.

EIGHTH SUBSPECIES.

COLUMNAR HEAVY-SPAR, *Jameson.*—Stangenspath, *Werner.*

External Characters.—Colours yellowish, greyish, and greenish-white. Occurs crystallized, in acicular oblique four-sided prisms, which are always columnarly aggregated, and intersect each other. Externally frequently invested with iron-ochre, but when unsoiled, shining and pearly. Cleavage the same as that of lamellar heavy-spar. Fragments indeterminate angular, and rather sharp-edged. Translucent. Specific gravity, 4.500.

Constituent Parts.—	Barytes, .	63.00
	Sulphuric Acid,	33.00
	Strontian Earth,	3.10
	Oxide of Iron,	1.50
	Water, -	1.20

Lampadius.

Geognostic and Geographic Situations.—It was formerly found in the vein of Lorenzgegentrum, near Freyburg in Saxony, along with ores of different kinds, and also fluor-spar, quartz, and straight and curved lamellar heavy-spar.

NINTH SUBSPECIES.

PRISMATIC HEAVY-SPAR, *Jameson.* Saulenspath, *Werner.*

External Characters.—Principal colours grey, white, greenish olive-green, flesh-red, and indigo-blue. Seldom occurs massive, or in angulo-granular and promiscuous prismatic concretions, generally crystallized, and in the following figures:

1. Slightly oblique four-sided prism, rather acutely bevelled on the extremities, and the bevelling planes set on the acuter lateral edges. 2. Oblique four-sided prism, rather acutely acuminated on the extremities with four planes, which are set on the lateral edges. 3. Unequiangular six-sided prism, with two opposite acuter lateral edges, and with the same terminal bevelment and acuminations as in figures 1 and 2. 4. Flat double four-sided pyramid, in which the lateral planes of the one are set on the lateral planes of the other.

Crystals middle-sized and small, and generally promiscuously aggregated. Surface of crystals splendent, and lateral planes transversely streaked. Internally shining or splendent, and lustre pearly, inclining to resinous. Alternates from translucent to semi-transparent. Specific gravity, 4.471, *Breithaupt*.

Geognostic Situation.—Occurs in veins, along with fluor-spar, and ores of silver and cobalt; in gneiss, mica-slate, and other primitive rocks. It is rare in clay-slate, and very rare in secondary rocks.

Geographic Situation.—Occurs at Kongsberg in Norway; Mies in Bohemia; and Freyberg, Marienberg, and Ehrenfriedersdorf, in Saxony; Roya in Auvergne.

4. Axifrangible Baryte, or Celestine, *Jameson*.—Axentheilender Hal-Baryt, *Mohs*. Zolestein, *Werner*.

Prism =104° 48′. The most distinct cleavage is that at right angles to the axis of the prism; another less distinct cleavage is parallel with the lateral planes of the prism. Hardness =3.0—3.3. Sp. gravity =3.6—4.0.

This species is divided into five subspecies, viz. Foliated Celestine, Prismatic Celestine, Fibrous Celestine, Radiated Celestine, and Fine Granular Celestine.

First Subspecies.

Foliated Celestine, *Jameson*.—Blattricher Celestin, *Karsten*. Schaaliger Zolestin, *Werner*.

External Characters.—Its colours are milk-white, blue, and red. Occurs massive; also in lamellar distinct concretions, which are generally straight, or slightly curved, and in which the surfaces are smooth and shining; and crystallized in the following figures: 1. Rectangular four-sided table, in which the terminal planes are bevelled, and the lateral planes are truncated. 2. Rectangular four-sided table, bevelled on the terminal edges. Crystals are middle-sized and small, and frequently rest on each other, or intersect each other. Externally shining and splendent; internally shining and pearly, inclining to vitreous. Fracture uneven. Fragments rhomboidal, or indeterminate angular, and rather sharp-edged. Is translucent, semi-transparent, or tranparent. Is rather sectile, and very easily frangible.

Chemical Characters.—It melts before the blowpipe into a white friable enamel, without very sensibly tinging the flame: after a short exposure to heat it becomes opaque, and has then acquired a somewhat caustic acrid flavour, very different from that of sulphuretted hydrogen, which heavy-spar acquires in similar circumstances. These characters apply also to the other subspecies.

Constituent Parts.

Strontian and Sulphuric Acid	97.601
Sulphate of Barytes	00.975
Silica	00.107
Oxide of Iron, and intermixed Hydrate of Iron	00.646
Water,	00.248—99.577

Stromeyer, in Got. Gel. Anz. 1812, 22, 114.

Geognostic and Geographic Situations.—Occurs in trap-tuff in the Calton Hill at Edinburgh,* and in red sandstone at Inverness. Is frequent along with some of the other subspecies at Aust Passage, and elsewhere in the neighbourhood of Bristol, and in the islands in the Bristol Channel, particularly in Barry Island, on the coast of Glamorganshire; also in amygdaloid at Bechely, in Glocestershire;† and it has been found on the banks of the Nidd, near Knaresborough, Yorkshire.

Second Subspecies.

Prismatic Celestine, *Jameson*.—Saulenförmiger Zölestin, *Werner*.

External Characters.—Colours white and blue. Occurs massive, also in distinct concretions, which are thick, straight, and wedge-shaped prismatic; but most frequently crystallized. The following are the most frequent crystallizations: 1. Long oblique four-sided prism, flatly bevelled on the extremities, the bevelling planes set on the obtuse lateral edges. Sometimes the angles between the bevelling and lateral planes are more or less deeply truncated, and thus form a four-planed acumination, in which the acuminating planes are set on the lateral edge. 3. Sometimes the acute edges of the preceding figure are truncated, and thus a six-sided prism is formed. Crystals middle-sized, and scopiformly aggregated, under an acute angle, and forming druses. Externally smooth, splendent, and resinous. Internally glistening and pearly, inclining to resinous. Cleavage the same as in the foliated subspecies. Fracture uneven. Fragments wedge-shaped and indeterminate angular. Is translucent, or transparent. In other characters it agrees with the preceding subspecies.

		Sicily.
Constituent Parts.—Strontian		54
	Sulphuric Acid	46—100

Vauquelin.

Geognostic and Geographic Situations—It occurs in drusy cavities in a bed of sulphur, which is associated with gypsum and marl, in the valleys of Noto and Mazzara, in Sicily.

Third Subspecies.

Fibrous Celestine, *Jameson*.—Fasriger Zölestin, *Werner*.

External Characters.—Colours blue, grey, and white. Occurs massive, also in distinct concretions, which are straight, parallel, and sometimes curved, fibrous. Internally glistening and pearly. Cleavage indistinct. Fragments splintery. Translucent. In other characters it agrees with the preceding species.

Constit. Parts.—Strontian		56.0
	Sulphuric Acid	42.0—98.0

Klaproth, Beit. b. ii. s. 97.

Geognostic and Geographic Situations.—Occurs in the red sandstone formation near Bristol; imbedded in marl, which is probably connected with gypsum, at Frankstown in Pennsylvania; and at Bouveron, near Toul, in the department of Meurthe in France.

Fourth Subspecies.

Radiated Celestine, *Jameson*.—Strahliger Zölestin, *Werner*.

External Characters.—Colour milk-white, which rarely approaches to yellowish and snow white. Occurs massive; also in prismatic concretions, which are scopiform radiated, collected into others which are wedge-shaped, and these again into very large and angulo-granular concretions. Internally shining and splendent, and lustre pearly, slightly inclining to vitreous. Frag-

* It was discovered in the Calton Hill by Mr. Sivright of Meggetland.
† It was discovered in the Becheley amygdaloid by Dr. Daubeny.

ments wedge-shaped and splintery. Translucent or semitransparent. In other characters agrees with the other subspecies.

FIFTH SUBSPECIES.

FINE GRANULAR CELESTINE, *Jameson.*—Fein Körniger Zolestin, *Werner.*

External Characters.—Colours greyish and yellowish-grey, and the first inclines sometimes to olive-green. Occurs massive, in fine granular concretions, in spheroidal or reniform masses, which are often traversed by fissures that divide its surface into quadrangular pieces, which are sometimes lined with minute crystals of celestine. Towards the surface it has a marly aspect. Internally dull and glimmering, and pearly. Fracture fine splintery, passing into uneven. Fragments blunt-edged. Opaque, or translucent on the edges. In other characters it agrees with the preceding subspecies.

Chemical Characters.—	Sulphate of Strontian	91.42
	Carbonate of Lime	8.33
	Oxide of Iron .	0.25
		100.00

Vauquelin, in Brongniart's Mineralogie, t. i. p. 258.

Geognostic and Geographic Situations.—Occurs imbedded in marly clay, with gypsum, at Montmartre, near Paris; and is said to form a whole bed in Champagne.

GENUS VI. LEAD-SPAR.

One and three axes. Cleavage rhomboidal, pyramidal, prismatic. Hardness ranges from 2.5 to 4.0. If above 3.5 the specific gravity is equal to 6.5 and more. Specific gravity ranges from 6.0 to 7.2.

This genus contains five species, viz. 1. Di-prismatic, or white lead-spar. 2. Rhomboidal, or green and brown lead-spar. 3. Prismatic or red lead-spar. 4. Pyramidal, or yellow lead-spar. 5. Tri-prismatic, or lead-vitriol.* Corneous lead, Arseniate of lead, Native minium.

1. DI-PRISMATIC LEAD-SPAR, *Jameson.* Di-prismatischer Blei-Baryt, *Mohs.*

Vertical prism = 117° 4′. Horizontal prism in the direction of the smaller diagonal = 109° 30′. Cleavage the same. Hardness = 3.0—3.5. Sp. gr. = 6.2—6.6.

This species is divided into three subspecies, viz. White lead-spar, Black lead-spar, and Earthy lead-spar.

FIRST SUBSPECIES.

WHITE LEAD-SPAR, *Jameson.* Weiss-Bleierz, *Werner.* Plomb carbonaté, *Hauy.*

External Characters.—Its colours are white, yellow, brown, and grey. It has sometimes a tempered steel tarnish. It is sometimes coloured externally yellow or brown, by yellow or brown iron-ochre; occasionally green, by earthy malachite; and blue, by earthy blue copper. It occurs massive, disseminated, in membranes, seldom reticulated; and crystallized in the following forms:—1. Unequiangular six-sided prism, in which the terminal edges are truncated. 2. Unequiangular six-sided prism, acutely acuminated with six planes, which are set on the lateral planes. 3. Acute double six-sided pyramid, which is perfect. 4. Unequiangular six-sided prism, acuminated with four planes, two of which are set on the lateral planes, bounded by the obtuse lateral edges, but the other two are set on the acuter lateral edges. 5. Acute oblique double four-sided pyramid, in the lateral planes of the one are set on the lateral planes of the other. It is the preceding figure without the prism. 6. Long acicular and capillary crystals, columnarly aggregated. 7. Occurs also in twin and triple crystals. The crystals are usually small, and very small; seldom middle-sized; are often long and acicular, also broad and tabular. Crystals occur superimposed, and either single or in druses; more frequently columnarly and scopiformly, or promiscuously aggregated. Externally, it alternates from specular splendent to glistening. Internally, it alternates from shining to glistening, and the lustre is adamantine, sometimes inclining to semimetallic, sometimes to resinous. Fracture is small conchoidal, which sometimes passes into uneven and splintery. Fragments are indeterminate angular, and rather sharp-edged. Alternates from translucent to transparent; and it refracts double in a high degree. Brittle, and very easily frangible.

		Leadhills.
Constituent Parts.—	Oxide of lead	82
	Carbonic acid	16
	Water	2—100

Klaproth, Beit. b. iii. s. 168.

Chemical Characters.—It is insoluble in water. It dissolves with effervescence in muriatic and nitric acids. Before the blowpipe it decrepitates, becomes yellow, then red, and is soon reduced to a metallic globule.

Geognostic Situation.—It occurs in veins, and sometimes also in beds, in gneiss, mica-slate, clay-slate, foliated granular limestone, grey-wacke, grey-wackeslate, and secondary limestone.

Geographic Situation.—It occurs at Leadhills in Lanarkshire, in veins that traverse transition rocks, in which it is associated with galena or lead-glance, earthy white lead-spar, green lead-spar, lead-vitriol or sulphat of lead, sparry iron, iron-pyrites, brown hematite, calamine, and blue copper; and the vein-stones are quartz, lamellar heavy-spar, calcareous-spar, brown-spar, and mountain-cork. It is found also with galena or lead-glance at Allonhead and Teesdale in Durham; with the same ore at Alston in Cumberland, and Snailback in Shropshire.

SECOND SUBSPECIES.

BLACK LEAD SPAR, *Jameson.* Schwarz Bleierz, *Werner.*

External Characters.—Its colour is greyish-black, of different degrees of intensity, which sometimes passes into ash-grey. Occurs massive, disseminated, corroded, cellular, and seldom crystallized, in small and very small six-sided prisms. The surface of the crystals is sometimes drusy, sometimes smooth, and sometimes longitudinally streaked. Externally it is generally splendent, and sometimes shining. Internally it is only shining, sometimes passing into glistening, and the lustre is metallo-adamantine. The fracture is small-grained uneven, which sometimes passes into imperfect conchoidal. Alternates from translucent to opaque. Its streak is whitish-grey. In other characters agrees with the preceding.

Constituent Parts.—	Oxide of lead	79
	Carbonic acid	18
	Carbon	2—99

Lampadius, Handb. Zu. Chem. Anal.

Geognostic Situation.—It generally occurs in the upper part of veins, associated with white lead-spar, and galena or lead-glance.

Geographic Situation.—It occurs at Leadhills; at Fair Hill and Flow Edge, Durham.

THIRD SUBSPECIES.

EARTHY LEAD-SPAR, *Jameson.* Bleierde, *Werner.*

This subspecies is divided into two kinds, viz. Indurated earthy lead-spar, and Friable earthy lead-spar.

First Kind.

INDURATED EARTHY LEAD-SPAR. *Jameson.* Verhärtete Bleierde, *Werner.*

External Characters.—Its most frequent colours are grey, from which it passes on the one side into yellow, on the other into brown. It occurs also smoke-grey, bluish-grey, and light-brownish red. It occurs massive. Internally it is glimmering, inclining to glistening; and the lustre is resinous*. The fracture is small and fine grained uneven, which passes on the one side into fine splintery, on the other into earthy. The fragments are indeterminate angular, and blunt-edged. Is usually opaque, or extremely faintly translucent on the edges. It yields a brown-coloured streak

Chemical Characters.—It is very easily reduced before the blowpipe; effervesces with acids, and becomes black with sulphuret of ammonia.

		Tarnowitz.
Constit. Parts.—	Oxide of lead	66.00
	Carbonic acid	12.00
	Water	2.25
	Silica	10.50
	Alumina	4.75
	Iron and oxide of manganese	2.25
		97.75

John, Chem. Unt. b. ii. s. 229.

Geognostic Situation.—The yellow-coloured varieties occur in a bed in primitive limestone in the Bannat; the grey-coloured varieties occur sometimes in veins, sometimes in beds, and either in transition or secondary rocks.

Geographic Situation.—It is found in the lead veins of Wanlockhead and Leadhills; also at Grassfield Mine near Nenthead in Durham, and in Derbyshire.

Second Kind.

FRIABLE EARTHY LEAD-SPAR, *Jameson.* Zerreibliche Bleierde, *Werner.*

External Characters.—Its colours are yellowish-grey and straw-yellow, which sometimes approaches to sulphur-yellow and lemon-yellow. It occurs massive, disseminated, and in crusts. It is composed of dull dusty particles, which are feebly cohering. Soils feebly. It is meagre, and rough to the feel. It is heavy.

Geognostic Situation.—It occurs on the surface, or in the hollows of other minerals, and is usually accompanied with galena or lead-glance and lead-spars.

Geographic Situation.—It is found at Wanlockhead and Leadhills; Zellerfeld in the Hartz.

2. RHOMBOIDAL LEAD-SPAR, *Jameson.*—Rhomboedrisches Blei Baryt, *Mohs.*

Di-rhomboid = 141° 47′, 81° 46′. Cleavage in the direction of the faces of the rhomboid, and in the direction of the lateral faces of the six-sided prism. Hardness = 3.5, 4.0. Specific Gravity = 6.9—7.2.

This species contains two subspecies, viz. Green lead-spar and Brown lead-spar.

FIRST SUBSPECIES.

GREEN LEAD-SPAR, *Jameson.*—Grün Bleierz, *Werner.* Plomb phosphate, *Hauy*

External Characters.—Its colours are green, yellow, and white. It seldom occurs massive, sometimes stalactitic, reniform, and botryoidal, sometimes in distinct concretions, which are granular or prismatic; but most commonly crystallized. The following are the secondary forms: 1. Equiangular six-sided prism. 2. Six-sided prism, truncated on all the lateral edges, thus forming a twelve-sided prism. 3. Six-sided prism, flatly acuminated on the extremities with six planes, which are set on the lateral planes. The crystals are small, and very small, seldom middle-sized; they are superimposed, in druses, or scalarwise, or rose-like aggregated. Sometimes they form velvety or moss-like drusy crusts. Externally it is smooth and shining, or splendent; internally glistening, and the lustre is resinous. The fracture is small grained uneven, passing on the one hand into splintery, on the other into conchoidal. The fragments are indeterminate angular, and blunt-edged. It is more or less translucent, seldom nearly transparent, and is sometimes only translucent on the edges. It is brittle, and easily frangible.

Chemical Characters.—It dissolves in acids without effervescence.

		Wanlockhead.
Constit. Parts.—	Oxide of lead	80.00
	Phosphoric acid	18.00
	Muriatic acid	1.62
	Oxide of iron	a trace—99.96.

Geognostic Situation.—It occurs in veins and beds in primitive, transition, and secondary rocks.

Geographic Situation.—It occurs along with galena or lead glance, and other ores of lead, at Leadhills and Wanlockhead. In England, it is met with at Alston in Cumberland, Allonhead, Grasshill, and Teesdale, in Durham, and Nithisdale in Yorkshire.

SECOND SUBSPECIES.

BROWN LEAD SPAR, *Jameson.* Braun Bleierz, *Werner.* Plomb phosph. é *Hauy.*

External Characters.—Colour clove-brown, of different degrees of intensity, rarely approaching to liver-brown, sometimes so pale that it inclines to white. Occurs massive, also in distinct concretions, which are thin prismatic, and curved lamellar; and crystallized in the following figures: 1. Equiangular six-sided prism, which is sometimes bulging. 2. Six-sided prism, converging towards both ends, and thus inclining to the pyramidal form. 3. Acute double three-sided pyramid, in which the lateral planes of the one are set on the lateral planes of the other, and in which the common basis is sometimes more or less deeply truncated. The crystals are middle sized and small, sometimes short and acicular, singly imbedded, or scopiformly or globularly aggregated. Surface of the crystals is sometimes blackish or yellowish brown, and rough. Internally it is

* This lustre is accidental, and appears to be owing to intermixed white lead-ore or lead-vitriol.

glistening, and the lustre resinous. Fracture small and fine-grained uneven, and sometimes passes into small splintery. Fragments indeterminate angular. Feebly translucent, or translucent on the edges. The streak is greyish-white. Rather brittle, and easily frangible.

		From Huelgoet in Brittany.
Constituent Parts.—Oxide of lead		78.58
	Phosphoric acid	19.73
	Muriatic acid	1.65—99.96

Klaproth, Beit. b. iii. s. 157.

Geognostic Situation.—It occurs in veins that traverse gneiss, clay-slate, and porphyry. The veins generally contain lead and silver ores, also native silver, iron and copper pyrites, malachite, blende, ochry ironstone, heavy-spar, and quartz.

Geographic Situation.—*Europe.* It is found at Mies in Bohemia; near Schemnitz in Hungary; Saska in the Bannat; Zschoppau in Saxony; Huelgoët and Poullaouen in Lower Brittany.

America.—Zimapan in Mexico.

3. Prismatic Lead-Spar, or Red Lead-Spar,—*Jameson.*—Prismatischer Blei-Baryt, *Mohs.* Roth-Bleierz, *Werner.* Plomb chromaté, *Hauy.*

Prism unknown. Cleavage in the direction of a rectangular prism. Hardness = 2.5. Sp. gr. = 6.0,—6.1.

External Characters.—Colour hyacinth-red, more or less deep or pale. Seldom occurs massive, generally in flakes; and crystallized in the following figures:

1. Long slightly oblique four-sided prism. 2. Prism acutely and obliquely bevelled on the extremities, the bevelling planes set on the lateral edges. 3. Prism acuminated with four planes, which are set on the lateral planes.

Crystals generally small, thin, and always superimposed. Lateral planes formed by bevelment longitudinally streaked, the other planes smooth, shining or splendent. Internally shining or splendent, and the lustre adamantine. Fracture small-grained uneven, sometimes passing into imperfect and small conchoidal. Fragments indeterminate angular, and rather sharp-edged. More or less translucent. Gives a streak, of a yellow intermediate between lemon-yellow and orange-yellow. Almost sectile, and easily frangible.

Chemical Characters.—Before the blowpipe it crackles and melts into a grey slag. With borax it is partly reduced. It does not effervesce with acid.

Constituent Parts.—Oxide of Lead,		63.96
	Chromic Acid,	36.40—100.36

Vauquelin, Journ. des Mines, n. 34. 737.

Geognostic and Geographic Situations.—It occurs in veins in gneiss, in the gold mines of Beresofsk, in the Uralian mountains. In these mines, it is associated with brown iron-ore, cubes of iron-pyrites, native gold, green lead-spar, galena, and quartz.

Use.—In Russia, a very beautiful and costly orange-yellow colour is prepared from it, and which is used by painters.

4. Pyramidal Lead Spar, or Yellow Lead-Spar, *Jameson.*—Pyramidal Blei-Baryt, *Mohs.* Gelb Bleierz, *Werner.* Plomb molybdate, *Haüy.*

Pyramid = 99° 40′; 131° 45′. Cleavage in the direction of the faces of the pyramid, or in the direction of the terminal faces of a rectangular four-sided prism. Hardness = 3. Sp. gr. = 6.5. 6.8.

External Characters.—Most frequent colour wax-yellow. Occurs massive, in crusts, cellular; and crystallized in the following figures:

1. The pyramid truncated on the angles and summits. 2. The pyramid so deeply truncated in all the angles, and on the common base, that the original faces disappear, when there is formed a regular eight-sided table, which is sometimes so thick as to appear as an eight-sided prism. Sometimes four of the terminal edges are truncated, when a twelve-sided table is formed. 3. Pyramid deeply truncated on the summits, and on the common base, and the angles of the common base bevelled, which gives rise to the rectangular four-sided table, bevelled on the terminal edges. 4. Pyramid truncated on the lateral edges, which gives rise to the double eight-sided pyramid. When this figure is deeply truncated on the summits, there is formed, 5. A regular eight-sided table, bevelled on the terminal planes.

Tables usually broad and thin, alternate from small to very small, but are seldom middle-sized. Frequently intersect each other, and are often closely aggregated. Externally generally splendent or shining; internally shining or glistening, and the lustre resinous, inclining to adamantine. Fracture small and fine-grained uneven, or small conchoidal. Fragments indeterminate angular, and rather sharp-edged. Generally translucent, or only translucent on the edges; some rare crystals are semi-transparent. Rather brittle, and easily frangible.

Chemical Characters.—It decrepitates before the blowpipe, and then melts into a dark greyish-coloured mass, in which the globules of reduced lead are dispersed.

Constituent Parts.—Oxide of Lead,		58.40
	Molybdic Acid,	38.00
	Oxide of Iron,	2.08
	Silica . .	0.28—96.66

Hatchett, Phil. Trans. for 1796.

Geognostic and Geographic Situations.—It occurs at Bleiberg in Carinthia, in a compact limestone; also in the Maukeriz, near Brixlegg in the Tyrol; at Annaberg in Austria, and Rezbanya in Transylvania.

5. Tri-prismatic Lead-Spar, or sulphate of lead, *Jameson.*—Tri-prismatischer Blei Baryt, *Mohs.* Vitriol Bleierz, *Werner.* Plomb Sulphaté, *Haüy.*

The vertical prism = 120°; horizontal prism in the direction of the longer diagonal = 70° 31′; and in the smaller 101° 32′. Cleavage is the same. Hardness = 3.0. sp. gr. = 6.3.

External Characters.—Colours yellowish and greyish-white, occasionally stained pale-yellowish, from brown iron-ochre. Occurs massive, disseminated, and in angulo granular distinct concretions, but most frequently crystallized. The following are the principal crystallizations:

1. Oblique four-sided prism, acutely bevelled on the extremities, and the bevelling planes set on the acuter lateral edges. 2. Broad rectangular four-sided pyramid.

Crystals small, and very small, seldom middle-sized; and occur in druses, or superimposed. Externally splendent and shining; internally shining, and the lustre adamantine. Fracture small conchoidal. Fragments indeterminate angular, and rather blunt-edged. Alternates from transparent to translucent. Streak white. Rather brittle, and easily frangible.

Chemical Characters.—It decrepitates before the blowpipe, then melts, and is soon reduced to the metallic state.

		Wanlockhead.
Constituent Parts.—Oxide of Lead,		70.50
Sulphuric Acid,		25 75
Water of Crystallization,	. .	2.25—98.0

Klaproth, Beit. b. iii. s. 164. and 166.

Geognostic and Geographic Situations.—It occurs in veins along with galena and lead-glance, and different spars of lead, at Wanlockhead in Dumfriesshire, and Lead Hills in Lanarkshire; at Pary's Mine in Anglesey, and Penzance in Cornwall. On the Continent, it is met with at Zellerfeld in the Hartz, and in the Westerwald mountains.

* Corneous Lead (a.) *Jameson.*—Hornblei, *Werner.*

External Characters.—Colours greyish-white, and yellowish-grey, passing into pale wine-yellow. Occurs crystallized in oblique four-sided prisms. Internally splendent, and lustre adamantine. Has a threefold cleavage, the cleavages parallel to the planes of the four-sided prism. Fracture conchoidal. More or less transparent. Is soft; rather softer than white lead-spar. Is sectile, and easily frangible. Specific gravity, 6.065, *Chenevix.*

Chemical Characters.—On exposure to the blow-pipe or charcoal, it melts into an orange-coloured globule, and appears reticular externally, and of a white colour when solid; when again melted it becomes white; and on increase of the heat the acid flies off, and minute globules of lead remain behind.

Constituent Parts.—Oxide of Lead,	85.5
Muriatic Acid,	8.5
Carbonic Acid,	6.0—100.0

Klaproth, Beit. b. iii. s. 144.

Geographic Situation.—*Europe.*—In Cromford Level near Matlock in Derbyshire; and at Hausbaden, near Badweiler in Germany.

America.—In the neighbourhood of Southampton in the United States.

*Arseniate of lead, *Jameson.*—Bleiblüthe, *Hausmann.*

This species is divided into three subspecies, viz. Reniform arseniate of Lead. Filamentous arseniate of Lead, and Earthy arseniate of Lead.

First subspecies.

Reniform arseniate of lead, *Jameson.*—Bleiniere, *Hausmann.*

External Characters.—Colours on the fresh fracture reddish-brown and brownish-red; externally ochre-yellow, and straw-yellow. Occurs reniform and tuberose; also in curved lamellar concretions. Internally shining and resinous. Fracture conchoidal, sometimes inclining to even and uneven. Opaque. Soft and brittle. Specific gravity 3.933, *Karsten.*

Chemical Characters.—It is insoluble in water. Before the blowpipe on charcoal it gives out arsenical vapours; and is more or less perfectly reduced. It colours glass of borax lemon-yellow

Constituent Parts —Oxide of Lead,	35 00
Arsenic Acid,	25.00
Water, .	10.00
Oxide of Iron,	14.00
Silver, .	1.15
Silica, .	7.00
Alumina, .	2.00—95.15

Bindheim, in Beob. u. Endeck. de Berl. Ges. Natf. Fr. iv. s. 374.

Geographic Situation.—It has been hitherto found only in one mine, near Nertschinsky in Siberia.

Second Subspecies.

Filamentous arseniate of lead, *Jameson.*—Flockenerz, *Karsten.*

External Characters.—Colours green and yellow. Occurs massive, in granular concretions, and either in small acicular six-sided prisms, which are collected into flakes, or in very delicate capillary silky fibres, which are transparent, slightly flexible, and easily frangible. Specific gravity 5.0, 6.4.

Constituent Parts.—Oxide of Lead,	69.76
Arsenic Acid,	26.04
Muriatic Acid,	1.58 *Gregor.*

Geographic Situation.—It occurs in the mine of Huel-Unity in Gwennap in Cornwall; at St. Prix, in the Department of the Soane and Loire in France.

Third Subspecies.

Earthy arseniate of lead, *Jameson.*—Erdige Bleiblüthe, *Hausmann.*

External Characters.—Colour yellow. Occurs in crusts. Fracture earthy. Friable.

Geognostic and Geographic Situations.—It occurs along with filamentous arseniate of lead at St. Prix; and also near St. Oisans.

* Native minium, or native red oxide of lead, *Jameson.*—Naturliche Menninge, Roth Bleioxyd, *Hausmann.*

External Characters.—Colour scarlet-red. Occurs massive, amorphous, and pulverulent; but when examined by the lens, exhibits a crystalline structure, like that of galena, on which it generally rests.

Chemical Characters.—Before the blowpipe, on charcoal, it is first converted into litharge, and then into metallic lead.

Geognostic and Geographic Situations.—It is found in Grassington Moor, Craven; Grasshill Chapel, Wierdale, Yorkshire. On the Continent it is found in the mine of Hausbaden, near Badenweiler, on galena, and associated with quartz.

Order III.—KERATE.†

No metallic lustre. Streak colourless. Sectile. Cleavage is neither distinctly axifrangible nor prismatoidal. Hardness ranges from 1 to 2. Specific gravity from 4 to 6.

Genus I.—CORNEOUS SILVER.

Three axes. Cleavage invisible. Hardness=1.0,—2.0. Spec. grav.=4.6.

(*a*) The minerals marked * are not yet included in the Genus Lead-spar, as their characters have not been completely ascertained.
† *Kerate*, from the Greek word κερας, *horn*, given to it on account of the species resembling horn in general aspect and tenacity.

This genus contains one species, viz. Hexahedral Corneous Silver. * Earthy Corneous Silver.

1. Hexahedral Corneous Silver, *Jameson.*—Hexedrisches Perl Kerat, *Mohs.* Hornerz, *Werner.* Argent muriaté, *Haüy.*

Tessular. Cleavage not visible. Malleable.

External Characters.—Most frequent colour pearl-grey, from which it passes on the one side into blue, on the other white, and further into leek-green. On exposure to light, it becomes brownish. Occurs massive in prismatic and granular concretions, in thick flakes, disseminated, in egg-shaped pieces, hollow in the centre, and the hollows lined with crystals. The crystals are the following:

1. Cube. 2. Octahedron. 3. Rhomboidal dodecahedron.

Crystals small and very small, occasionally aggregated in rows, or in a scalar-like form. External surface smooth, sometimes marked with little hollows. Externally shining, but becomes gradually duller on exposure: internally intermediate between shining and glistening, and the lustre resinous. Fracture conchoidal, sometimes inclines to earthy. Fragments indeterminate angular and blunt-edged. Translucent, or only feebly translucent on the edges. Retains its colour, and becomes more shining in the streak. Is malleable. Flexible, but not elastic.

Chemical Characters.—It is fusible in the flame of a candle.

Constituent Parts.—	Silver, .	67.75
	Muriatic Acid,	14.75
	Oxygen, .	6.75
	Oxide of Iron,	6.00
	Alumina, .	1.75
	Sulphuric Acid,	0.25—97.25

Klaproth, Beit. b. iv. s. 13.

Geognostic Situation.—It occurs in silver veins, and generally in their upper part. These veins traverse gneiss, mica-slate, clay slate, grey-wacke, porphyry, and limestone, and contain, besides the corneous silver, various ores.

Geographic Situation.—*Europe.*—At Huel-Mexico in Cornwall.

Asia.—In Siberia, it occurs along with native gold.

America.—This mineral, which is so seldom found in Europe, is very abundant in the mines of Catorce, Fresnillo, and the Cerro San Pedro, near the town of San Luis Potosi.

Earthy Corneous Silver-Ore (†), *Jameson.*—Erdiges Hornerz, *Karsten.*

External Characters.—Internally the colour is pale mountain-green, inclining to greyish-white; externally it has a bluish-grey tarnish. Occurs in thick crusts. Internally dull. Fracture coarse and fine earthy. Fragments blunt angular. Very soft, almost friable. Streak shining and resinous. Sectile. Heavy.

Constituent Parts.—	Silver, . . .	24.64
	Muriatic Acid, .	8.28
	Alumina, with a trace of copper,	67.08—100.00

Klaproth, Beit. b. i. s. 137.

Geognostic and Geographic Situations.—It is found in veins that traverse transition rocks at Andreasberg in the Hartz.

Genus II.—CORNEOUS MERCURY.

Pearl Kerate, *Mohs.*

One axis. Cleaving very indistinct. Hardnes, = 1.0, 2.0. Sp. gr. =

This genus contains one species, viz. Pyramidal Corneous Mercury.

1. Pyramidal Corneous Mercury, *Jameson.*—Pyramidales Pearl Kerate, *Mohs.* Quecksilber Hornerz, *Werner.* Mercure muriaté, *Haüy.*

Pyramid unknown. Cleavage indistinct axifrangible, sectile.

External Characters.—Colour grey. Occurs very rarely massive, almost always in small vesicles crystallized in the interior. The crystals are the following:

1. Rectangular four-sided prism, acuminated on the extremities with four planes, which are set on the lateral planes. 2. Rectangular four-sided prism, acuminated with four planes, which are set on the lateral edges. 3. Double four-sided pyramid.

Crystals always so minute that it is with difficulty their forms can be determined. External surface sometimes smooth, sometimes drusy, and in general shining and adamantine. Internally shining, with an adamantine lustre. Has a single cleavage, which appears to be parallel with the terminal planes of the prism. Faintly translucent, or only translucent on the edges. Sectile, and easily frangible.

Chemical Characters.—It is totally volatilized before the blowpipe, and emits a garlic smell. It is soluble in water, and the solution mixed with lime-water gives an orange-coloured precipitate.

Constituent Parts.—	Oxide of Mercury,	76.00
	Muriatic Acid,	16.40
	Sulphuric Acid,	7.60—100.00

Klaproth.

Geognostic Situation.—In the quicksilver mines of the Palatinate, and Dutchy of Deux Ponts.

Geographic Situation.—It occurs in Bohemia, Deux Ponts, Palatinate, Upper Hessia; and at Almaden in Spain.

Order IV.—MALACHITE.

No metallic lustre. Streak blue, green, brown. If white, the specific gravity is 2.2 and less. Colour not inclining to yellow. Cleavage is neither distinctly axifrangible nor prismatoidal. Hardness ranges from 2 to 5. If the streak is brown, the hardness is less than 3.5. Specific gravity ranges from 2 to 4.6.; if it is less than 3.2, the hardness is below 3.

This Order contains four Genera, viz. 1. Copper-Green, 2. Malachite, 3. Olivenite, and, 4. Emerald-Copper.

Genus I.—COPPER-GREEN.

Trauben Malachit, *Mohs.*

Reniform; botryoidal. Streak white. Hardness = 2.0.—3.0. Sp. gravity = 2.0.—2.2.

(†) This mineral appears to be a mechanical mixture of corneous silver and clay, and hence it is placed beside it, but not as a variety of the species.

This genus contains one Species, viz. Common Copper-Green.

1. Common Copper-Green, or Chrysocolla.—*Jameson.*—Untheilbarer Trauben Malachit, *Mohs.*—Kupfergrün, *Werner.*

No cleavage.

This species is divided into three subspecies, viz. 1. Conchoidal Copper-Green, 2. Earthy Iron-shot Copper-Green, 3. Slaggy Iron-shot Copper-green.

First Subspecies.

Conchoidal Copper-Green, *Jameson.*—Kupfergrün, *Werner.*

External Characters.—Principal colour green. Occurs massive, disseminated, and coating or incrusting malachite, sometimes small reniform, and small botryoidal. Internally shining, passing into glistening; lustre resinous. Fracture small conchoidal. Fragments indeterminate angular, and more or less sharp-edged. It alternates from translucent to translucent on the edges. Colour not changed in the streak. Easily frangible, and rather brittle.

Chemical Characters.—Before the blowpipe, it becomes first black, then brown, but is infusible.

Constituent Parts.—	Copper, . . .	40.00
	Oxygen, . . .	10.00
	Carbonic Acid, .	7.00
	Water, . . .	17.00
	Silica, ...	26.00—00.100

Klaproth, Beit. b. i. s. 36.

Geognostic Situation.—It is met with in the same geognostic situations as malachite.

Geographic Situation.—It occurs in Cornwall, along with olivenite, and also in the vale of Newlands, near Keswick.

Siliceous Copper, *Jameson.* Kieselkupfer, *John.*

Its colours are asparagus-green, and celandine-green, inclining to sky-blue. Occurs in crusts. Dull, faintly glistening, and resinous. Fracture even or earthy. Opaque, or rarely translucent on the edges. Soft.

Constituent Parts.—Copper, 37.8. Oxygen, 8. Water, 21.8. Silica 2.9; and Sulphate of Lime, 3.

Second Subspecies.

Earthy Ironshot Copper-Green, *Jameson.*—Erdiches eisenschüssiges Kupfergrün, *Werner.*

External Characters.—Colour olive-green, which sometimes passes into pistachio-green, and inclines to leek-green. Occurs massive, and in crusts. Generally of friable consistence, and composed of dull, dusty particles, which are more or less cohering, and that do not soil. Compact varieties have an earthy fracture. Opaque. Very soft, passing into friable. Sectile, and easily frangible.

Third Subspecies.

Slaggy Ironshot Copper-Green, *Jameson.*—Schlackiges-eisenschüssiges Kupfergrün, *Werner.*

External Characters.—It is blackish-green, and dark pistachio-green. Occurs massive, and disseminated. Internally shining, glistening, lustre resinous. Fracture small conchoidal. Fragments indeterminate angular, and more or less sharp-edged. Opaque. Colour becomes paler in the streak. Soft, verging into very soft. Easily frangible.

Constituent Parts.—It is probably a compound of Conchoidal Copper-Green and Oxide of Iron.

Geognostic Situation.—Both subspecies usually occur together, and they frequently pass into each other.

Geographic Situation.—It occurs in Cornwall, along with olivenite.

Genus II.—MALACHITE.

Kalo Malachit, *Mohs.*

Three axes. Cleavage prismatic. Streak blue; green; very pure. Hardness = 3.5,—4.0. Sp. gravity = 3.5,—3.7.

This Genus contains two species, viz. 1. Blue Copper or Prismatic Malachite, and 2. Common or Acicular Malachite. * Brown Copper.

1. Blue Copper or Prismatic Malachite, *Jameson.*—Prismatischer Kalo-Malachit, *Mohs.* Kupferlazur, *Werner.*

Prism = . Cleavage uncertain. Streak blue.

This species is divided into two subspecies, viz. Radiated Blue copper, and Earthy Blue Copper. *Velvet Blue Copper.

First Subspecies.

Radiated Blue Copper, *Jameson.*—Feste Kupferlazur, *Werner.*

External Characters.—Principal colour azure-blue, which often passes into blackish-blue, seldomer into Berlin-blue and smalt-blue. Occurs massive, disseminated, in plates, in crusts; also globular, botryoidal, reniform, stalactitic, and cellular; in prismatic distinct concretions, which are straight, narrow, scopiform, and stellular, and these are again traversed by others which are curved lamellar. Sometimes there is a tendency to granular concretions. Very frequently crystallized. Generally occurs in oblique four-sided prisms, rather acutely bevelled on the terminal planes, and the bevelling planes set on the acuter lateral edges. Crystals small, and very small, seldom middle-sized. Sometimes aggregated in globular and botryoidal forms; other crystals occur in druses, or singly superimposed. External surface of the particular external shapes drusy and glimmering; that of the crystals sometimes smooth and splendent. Externally the crystallized varieties are shining, but the massive and particular external shapes dull. Internally shining and glistening, and lustre intermediate between vitreous and resinous. Fracture small and imperfect conchoidal. Fragments of the prismatic or radiated varieties wedge-shaped; those of the foliated and conchoidal splintery. Crystals translucent, passing into semi-transparent, sometimes only translucent on the edges. Colour becomes lighter in the streak. Brittle, and rather easily frangible.

Chemical Characters.—It is soluble with effervescence in nitric acid.

		Chessy.
Constituent Parts.—	Copper, . . .	56.00
	Carbonic Acid, .	25.00
	Oxygen, . . .	12.50
	Water, . . .	6.50—100.00

Vauquelin, An. du Mus. xx. p. 3.

Geognostic Situation.—This mineral occurs in veins that traverse primitive, transition, and secondary or flœtz rocks; in smaller quantity, and less frequently in beds.

Geographic Situation.—Occurs at Leadhills in Lanarkshire, and Wanlockhead in Dumfriesshire; Huel-Virgin and Carharrack in Cornwall.

SECOND SUBSPECIES.

EARTHY BLUE COPPER, *Jameson.*—Erdiger Kupferlazur, *Werner.*

External Characters.—Colour smalt-blue, which sometimes inclines slightly to sky-blue. Massive, often disseminated, thinly coating, and rarely small botryoidal. Of friable consistence, and composed of dull and fine dusty particles that soil very faintly, and which are more or less cohering.

Geognostic and Geographic Situations.—Occurs in small quantity, and usually accompanied with malachite and copper-green. In Silesia, found incrusting bituminous marl-slate; in Thuringia, coating varieties of the old red-sandstone; and in Siberia, disseminated in sandstone.

* VELVET-BLUE COPPER, *Jameson.*—Kupfersammterz, *Werner.* Kupfersammterz, *Karsten*, Tabel. s. 62. *Id. Hoff.* b. iv. s. 143.

External Characters.—Colour intermediate between smalt-blue and sky-blue, and sometimes passes into sky-blue. Occurs in very small and delicate capillary crystals, which generally form a velvety crust, and are seldom aggregated in balls. Externally and internally lustre glistening and pearly, or silky. Very soft.

Geognostic and Geographic Situations.—A very rare mineral, and has hitherto been found only at Oravicza in the Bannat, along with malachite and brown ironstone.

2. COMMON OR ACICULAR MALACHITE,† *Jameson.* Malachit, *Werner.*

Prism = . Cleavage uncertain. Streak green.

This species is divided into two subspecies, viz. Fibrous Malachite, and Compact Malachite. * Brown Copper.

FIRST SUBSPECIES.

FIBROUS MALACHITE, *Jameson.*—Fasricher Malachit, *Werner.*

External Characters.—Most common colour perfect emerald-green, sometimes inclining to grass-green, and sometimes to dark leek-green. Seldom massive, sometimes disseminated, tuberose, stalactitic, reniform, botryoidal, fruticose, most frequently as a coating, also in fibrous distinct concretions, which are delicate and scopiform or stellular, and collected into others which are large, coarse, and sometimes longish granular, or wedge-shaped. Frequently crystallized; and the following are the figures which have been observed:

1. Rather oblique four-sided prism, bevelled on the extremities, the bevelling planes set on the obtuse lateral edges. 2. The preceding figure truncated on the obtuse lateral edges, which thus forms a six-sided prism, in which the bevelling planes are set on two opposite lateral planes.

Crystals generally short, capillary, and acicular. When very short, they form velvety drusy pellicles; and when longer, they are scopiformly aggregated. Internally intermediate between glistening and glimmering, and the lustre pearly or silky. Fragments wedge-shaped and splintery. Crystals translucent, but the massive varieties only translucent on the edges, or opaque. Colour of the streak pale-green. Brittle, inclining to sectile, and easily frangible.

Chemical Characters.—Before the blowpipe it decrepitates and becomes black, and is partly infusible, partly reduced to a black slag.

		Chessy.
Constituent Parts.—Copper,	.	56 10
Carbonic Acid,		21 25
Oxygen,	.	14.00
Water,	.	8.75—100.00

An. Mus. t. xx. p. 8.

Geognostic Situation.—Occurs principally in veins that traverse primitive, transition, and secondary rocks.

Geographic Situation.—Occurs at Sandlodge, in Mainland, one of the Shetland Islands, in veins that traverse red sandstone, in which it is associated with grey copper, copper-pyrites, and brown iron-ore; at Landidno in Caernarvonshire; and in various mines in other parts of the world.

SECOND SUBSPECIES.

COMPACT MALACHITE, *Jameson.*—Dichter Malachit, *Werner.*

External Characters.—Colour intermediate between emerald-green and verdegris-green; but in general inclining more to the first. Colours often disposed in concentric delineations, and varied with dark-coloured dendritic markings. Occurs massive, disseminated, and in membranes; most frequently reniform and botryoidal, frequently tuberose, stalactitic, fruticose, cellular, and amorphous; also in distinct concretions, which are sometimes extremely delicate and scopiform fibrous; more frequently thin lamellar, or large, coarse, and small angulo-granular; and sometimes crystallized in oblique four-sided prisms. External surface of the particular shapes generally rough and drusy, seldomer smooth, and then it is shining and glistening. Surface of the distinct concretions apparently covered with a greenish-white film. Internally it passes from glistening through glimmering to dull, but most commonly glimmering, and the lustre silky. Fracture small and fine-grained uneven, which sometimes passes into small and flat conchoidal, and even. Fragments indeterminate angular, and rather sharp-edged. Opaque. Rather brittle, and easily frangible. Streak pale-green.

Chemical Characters and Constituent Parts nearly the same with the preceding subspecies.

Geognostic Situation.—It occurs in veins, which traverse primitive transition, and secondary rocks.

Geographic Situation.—*Europe.*—In the copper-mines of Huel-Carpenter and Huel-Husband, in Cornwall; in the copper-mines of Aardal in Norway; and in many other mines on the Continent of Europe.

Asia.—In the mines of Kolwyan, Gamasherk, Turja, &c. in Siberia, where the most beautiful and largest specimens of this mineral are met with, along with tile-ore, red copper-ore, brown iron-ore, copper-glance or vitreous copper, blue copper, copper-green, white lead-spar, brown spar, ironshot quartz, hornstone, &c. It is also met with in different parts of China.

Uses.—It was formerly esteemed as a precious stone, and was cut into ornamental forms of various descriptions. Even at present it is highly prized, and is cut into consoles, candlesticks, snuff-boxes, and other similar articles. Where it occurs in quantity, it is smelted

† The name of the species is derived from the word μαλαχη, *malva*, from the resemblance of its green colour to that of the *marsh-mallow.* The Greek word is sometimes corruptly written μολοχη, whence Pliny has derived the term *molochites:* "Non translucet molochites, spissius virens et crassius quam smaragdus, a colore malvæ nomine accepto."

as an ore of copper, and is sometimes used as a green pigment.

*Brown Copper.—Analysis of a new species of Copper-ore, by *Dr. Thomson*, Phil. Trans. for 1814.

External Characters.—Colour, when pure, dark blackish-brown; but very generally intermixed with malachite and red copper-ore, so that the colour appears a mixture of green, red, and brown, sometimes one and sometimes another prevailing. Small green veins of malachite likewise traverse it in different directions. Occurs massive, with numerous imbedded small rock-crystals. Lustre glimmering and resinous. Fracture small conchoidal, and sometimes inclining to foliated. Soft, being easily scratched by the knife. Sectile. Streak reddish-brown. Specific gravity, 2 620, *Thomson.*

Chemical Characters.—It effervesces in acids, and dissolves, letting fall a red powder. The solution is green or blue, according to the acid, indicating that it consists chiefly of copper.

Constituent Parts.—Carbonic Acid,	16 70	
Per-oxide of Copper,	60 75	
Per-oxide of Iron,	19.50	
Silica, .	2.10	
Loss, . .	0.95	100.00

Thompson, in Phil. Trans. for 1814.

Geognostic Situation.—It appears to occur in nests in primitive rocks, which are of greenstone, or some similar rock of the primitive trap series subordinate to mica-slate. It is associated with malachite.

Geographic Situation.—In the peninsula of Hindostan, near the eastern border of the Mysore country.

Genus III. OLIVENITE.

Oliven-Malachit, *Mohs.*

Many axes. Cleavage prismatic, tessular; streak blue, green, brown. If streak green or blue, the specific gravity is 4 and more, or 3 and less. Hardness from 2 5 to 5. Sp. gr. from 2.8 to 4.6.

This genus contains four species, viz. 1. Prismatic Olivenite, or Phosphat of Copper; 2 Di-prismatic Olivenite, or Lenticular Copper; 3. Acicular Olivenite; 4. Hexahedral Olivenite, or Cube-Ore, *Atacamite.

1. Prismatic Olivenite, or Phosphat of Copper, *Jameson.*—Prismatischer Oliven-Malachit, *Mohs.*

Prism =116°. Cleavage the same. Streak emerald green. Hardness =5. Sp. gr. =4.0—4.3.

External Characters.—Principal colour emerald-green, which passes into blackish-green; externally, sometimes greenish-black. Occurs massive, in imperfect reniform masses, with a very drusy surface, and in coarse fibrous distinct concretions, which are straight and scopiform. Crystals small and very small, superimposed and in druses. Externally shining; internally passes from shining, through glistening, to glimmering, and the lustre resinous, inclining to pearly. Fracture splintery. Fragments wedge-shaped splintery, or indeterminate angular, and rather blunt-edged. Opaque. Streak verdigris-green. Brittle, and easily frangible.

Chemical Characters.—On the first impression of the heat it fuses into a brownish globule, which, by the further action of the blowpipe, extends on the surface of the charcoal, and acquires a reddish-grey metallic colour.

Constituent Parts.—Oxide of Copper,	68.13	
Phosphoric Acid,	30.95	99.08

Klaproth, Beit. b. iii. s. 201.

Geognostic and Geographic Situations.—The principal locality of this rare mineral is Virneberg, near Rheinbreitenbach, on the Rhine, where it occurs along with quartz, calcedony, red copper-ore, and malachite, in greywacke.

II. Di-prismatic Olivenite, or Lenticular Copper, *Jameson.*——Di-prismatischer Oliven-Malachit, *Mohs*—Linsenerz, *Werner.*

Prism unknown. Cleavage in the direction of the terminal and bevelling faces of an oblique four-sided prism. Streak pale verdigris-green, and sky-blue. Hardness =2.5. Sp. gr. =2.8—2.9.

External Characters.—Colour sky-blue, which sometimes passes into verdigris-green. Scarcely occurs massive, generally crystallized:

1. Very oblique four-sided prism, acutely bevelled on the extremity, and the bevelling planes set on the obtuse lateral edges. 2. Very flat, longish, rectangular double four-sided pyramid, in which the lateral planes of the one are set on the lateral planes of the other.*

Crystals middle-sized and small, and sometimes crystallized in druses. Externally smooth and shining; internally glistening and shining, and pearly, inclining to vitreous. Fracture small-grained uneven, which sometimes passes into imperfect conchoidal. Fragments indeterminate angular, and rather sharp-edged. Translucent. Yields a pale verdigris-green, or sky-blue coloured streak. Brittle, and uncommonly easily frangible.

Chemical Characters.—Before the blowpipe it is converted into a black friable scoria.

Constituent Parts.—Oxide of Copper,	49	
Arsenic Acid, .	14	
Water, . .	35	98

Chenevix in Phil. Trans. for 1801.

Geognostic and Geographic Situations.—It has been hitherto found only in Cornwall, where it is associated with copper-mica, and other cupreous minerals.

III. Acicular Olivenite, *Jameson.*—Nadelförmiger Oliven-Malachit, *Mohs.*

Prism unknown. Cleavage unknown. Streak olive-green; brown. Hardness =3.0. Sp. gr. =4.2—4.6.

This species is subdivided into four subspecies, viz. Radiated Acicular Olivenite, Foliated Acicular Olivenite, Fibrous Acicular Olivenite, and Earthy Acicular Olivenite.

First Subspecies.

Radiated Acicular Olivenite, *Jameson.*—Strahlerz. *Werner.*

External Characters.—Externally colour dark verdigris-green, sometimes bordering on blackish-green; internally pale verdigris-green, either pure, or intermixed with sky-blue. Occurs massive, and flat reniform; also in radiated prismatic concretions, which are straight and scopiform; and crystallized in flat oblique four-sided prisms, acuminated with four planes. Crystals generally small, and superimposed. External surface of the reniform shape very drusy. Internally lustre intermediate between shining and glistening, and pearly. Fragments wedge-shaped. Translucent on the edges. Brittle, and easily frangible.

* The double four-sided pyramid is so flat that it has a lenticular aspect; hence the name *Lenticular Copper* given to this species.

Second Subspecies.

Foliated Acicular Olivenite, *Jameson.*—Blättriches Olivenerz. *Werner.*

External Characters.—Colour green. Seldom occurs massive, and in angulo-granular concretions, generally in drusy crusts, and in small crystals, which present the following varieties of form:

1. Oblique four-sided prism, acutely bevelled on the extremities, the bevelling planes set on the acute lateral edges. 2. Preceding figure, in which the obtuse lateral edges are more or less deeply truncated. 3. Acute double four-sided pyramid; sometimes the angles on the common base are flatly bevelled; and the bevelling planes are set on the lateral edges.

Crystals small, and very small, and always superimposed. Planes of the crystals smooth, shining, and splendent. Internally glistening, and lustre resinous, inclining to pearly. Fracture small and imperfect conchoidal, which passes into uneven. Fragments indeterminate angular, and rather sharp-edged. Ranges from translucent to translucent on the edges. Yields an olive-green coloured streak. Rather brittle, and easily frangible.

Chemical Characters.—Before the blowpipe, it first boils, and then gives a hard reddish brown scoria.

Constituent Parts.—Oxide of Copper,	60.0
Arsenic Acid,	89.7—99.7.

Chenevix, Phil. Trans. 1801.

Geognostic and Geographic Situations.—It has been hitherto found only in the copper-mines of Cornwall.

Third Subspecies.

Fibrous Acicular Olivenite, *Jameson.*—Fasriges Olivenerz. *Werner.*

External Characters.—Colours green, yellow, brown, and white. Colours sometimes arranged in curved and striped delineations. Occurs massive, and reniform; in fibrous concretions, which are delicate, straight, and scopiform, and these are collected into coarse or small granular concretions, and sometimes traversed by others, which are curved lamellar; also crystallized in capillary and acicular oblique four-sided prisms, in which the obtuse lateral edges are truncated, and bevelled on the extremities, the bevelling planes being set on the acute edges. Crystals small, and very small, and sometimes scopiformly aggregated. Internally the massive varieties are glistening or glimmering, with a pearly or silky lustre. Fragments indeterminate angular, and wedge-shaped. Opaque, seldom translucent on the edges, and only translucent in the crystals. Rather brittle. Fibres sometimes flexible.* Streak brown or yellow.

Constituent Parts.—Oxide of Copper,	50
Arsenic Acid, .	29
Water, . .	21—100

Chenevix, in Phil. Trans. for 1801.

Geognostic and Geographic Situations.—It is associated generally with the other arseniates of copper and various ores of copper. It occurs principally in Cornwall.

Fourth Subspecies.

Earthy Acicular Olivenite, *Jameson.*

External Characters.—Colour olive-green. Occurs massive, disseminated, and in crusts. Dull. Fracture fine earthy. Sometimes occurs in concentric lamellar distinct concretions. Opaque. Soft, and very soft.

Geognostic and Geographic Situations.—It occurs along with the other subspecies of olivenite in the copper-mines of Cornwall.

IV. Hexahedral Olivenite, or Cube-Ore, *Jameson.* Wurfelerez, *Werner.*

Tessular. Cleavage hexahedral. Streak olive-green; brown. Hardness = 2.5. Sp. gr. = 2.9 — 3.0.

External Characters.—Colour green. Occurs massive; and crystallized in the following figures:

1. Perfect cube. 2. Cube, in which four diagonally opposite angles are truncated. 3. Cube truncated on all the edges. 4. Cube truncated on all the edges and angles.

Crystals small and very small, and always superimposed and in druses. Planes of the crystals smooth and splendent. Internally glistening, and lustre intermediate between vitreous and resinous. Fragments indeterminate angular, and rather sharp-edged. Translucent, or translucent on the edges. Streak straw-yellow. Rather brittle, and easily frangible.

Chemical Characters.—Before the blowpipe it melts, and gives out arsenical vapours.

Constituent Parts.—Arsenic Acid, .	31.0
Oxide of Iron, .	45.5
Oxide of Copper, .	9.0
Silica, . .	4.0
Water, . . .	10.5—100

Chenevix, in Phil. Trans. for 1801.

Geognostic Situation.—It is found in veins, accompanied with ironshot quartz, copper-glance or vitreous copper, copper-pyrites, and brown iron-ore.

Geographic Situation.—It occurs in Tincroft, Carrarach, Muttrel, Huel-Gorland, and Gwenap mines in Cornwall.

* Atacamite, or Muriate of Copper, *Jameson.* Salzkupfererz, *Werner.*

This species is divided into two subspecies, viz. Compact and Arenaceous.

First Subspecies.

Compact Atacamite, or Muriate of Copper,† *Jameson.* Festes Salzkupfererz, *Werner.*

External Characters.—Colour green. Occurs massive, disseminated, imperfect reniform, in prismatic distinct concretions, which are short, small, and scopiform, also in granular concretions; in crusts or investing; and in short needle-shaped crystals, of the following forms:

1. Oblique four-sided prism, bevelled on the extre-

* The fibres are sometimes so delicate, so short, and so confusedly grouped together, that the whole appears like a dusty cottony mass, the true nature of which is discoverable only by the lens. At other times, this variety appears in thin laminæ, rather flexible, sometimes scarcely perceptible to the naked eye, sometimes tolerably large, and perfectly like Amianthus papyraceus.—*Bournon*, Phil. Trans. for 1801, part i. p. 180.

† We place this mineral immediately after the Genus Olivenite, on account of its resemblance to it; but want of accurate information prevents us from including it as a species of that genus.

mities; the bevelling planes set on the acute lateral edges. 2. The preceding figure, in which the acuter lateral edges are deeply truncated, thus forming a six-sided prism.

Internally shining and glistening, and pearly. Has an imperfect cleavage. Fragments indeterminate angular. Translucent on the edges. Soft. Brittle, and easily frangible. Specific gravity, 4.4?

Chemical Characters.—It tinges the flame of the blowpipe of a bright green and blue, muriatic acid rises in vapours, and a bead of copper remains on the charcoal. It is soluble in nitric acid without effervescence.

Constituent Parts.—	Oxide of Copper,	73.0
	Water,	16.9
	Muriatic Acid,	10.1—100.0

Klaproth, Beit. b. iii. s. 200.

Geognostic and Geographic Situations.—It occurs in veins in Chili; also at Virneberg near Rheinbretenbach on the Rhine, and at Schwartzenberg in Saxony. In the fissures of the lavas of Vesuvius, particularly those of the years 1804 and 1805.

Second Subspecies.

Arenaceous Atacamite, or Copper-Sand, *Jameson.*—Kupfersand, *Werner.*

External Characters.—Colour grass-green, inclining to emerald-green. Occurs in scaly particles, which are shining, glistening, and pearly. Does not soil. Translucent.

Constit. Parts.—	Oxide of Copper,	70.5
	Water,	18 1
	Muriatic Acid,	11.4
		100.0

Proust, Journ. de Phys. t. 50. p. 63.

Geognostic and Geographic Situations.—It is found in the sand of the river Lipes, 200 leagues beyond Copiapu, in the desert of Atacama, which separates Chili from Peru.

Genus IV. EMERALD COPPER.

Smaragd-Malachite, *Mohs.*

One axis. Cleavage rhomboidal. Streak. Hardness = 5.0. Sp. gr. = 3.3. — 34.

This genus contains but one species, viz. Rhomboidal Emerald Copper, or Dioptase.

1. Rhomboidal Emerald Copper, or Dioptase. *Jameson.*—Rhomboedrischer Smaragd-Malachite, *Mohs.* Kupfer-Schmaragd, *Werner.*

Rhomboid = 123° 58′. Cleavage rhomboidal.

External Characters.—Colour emerald green, which sometimes inclines to pistachio and blackish green. Occurs only crystallized. The only secondary form at present known, is the equi-angular six-sided prism, which is rather acutely acuminated on both extremities by three planes, which are set on the alternate lateral edges. Lateral planes smooth. Internally shining, and lustre pearly. Fracture small conchoidal. Translucent, passing to semi-transparent. Brittle, and easily frangible.

Chemical Characters.—It becomes of a chestnut-brown colour before the blow-pipe, and tinges the flame green, but is infusible; with borax it gives a bead or globule of copper.

Constituent Parts.—	Oxide of Copper,	28.57
	Carbonate of Lime,	42.85
	Silica,	28.57—99.99

Vauquelin, in Haüy, t. iii. p. 137.

Geognostic and Geographic Situations.—Found, according to Hermann, in the land of the Kirguise, 125 leagues from the Russian frontier, where it is associated with the fibrous and compact malachite, calcareous-spar, and limestone.

Order V. MICA.

If no metallic lustre, the specific gravity is above 2.2. Streak neither yellow nor dark-red. If the specific gravity is under 2.2. the lustre is perfectly metallic and shining. The cleavage is distinctly axifrangible and prismatoidal. The hardness varies from 1. to 2.5. Specific gravity ranges from 1.9 to 5.6.

This order contains seven genera, viz. 1. Copper-mica; 2. Uran-mica; 3. Cobalt-mica; 4. Antimony-mica; 5. Blue iron; 6. Graphite; 7. Mica; 8. Pearl-mica.

Genus I. COPPER-MICA.

Three axes. Cleavage prismatic. Streak green. Hardness = 2.0. Sp. gr. = 2.5 —2.6.

This genus contains one species, viz. prismatic copper-mica.

1. Prismatic Copper-Mica, *Jameson.*—Prismatischer Kupferglimmer, *Mohs.* Kupferglimmer, *Werner.*

Prism unknown. Cleavage prismatic.

External Characters.—Colour green. Occurs massive, disseminated, and in granular distinct concretions; seldom crystallized in very thin equi-angular six-sided tables, in which the alternate terminal planes are set on obliquely. Externally smooth and splendent; internally splendent, lustre pearly. Fracture small-grained, uneven, inclining to conchoidal. Fragments indeterminate angular and tabular. Massive varieties translucent; crystallized transparent. Streak green. Sectile. Rather brittle.

Chemical Characters.—It decrepitates before the blowpipe; and passes, first, to the state of a black spongy scoria, after which it melts into a black globule, of a slightly vitreous appearance.

Constit. Parts.	Oxide of Copper,	58
	Arsenic Acid,	21
	Water,	21——100

Chenevix, Phil. Tr. for 1801, p. 201.

Geognostic and Geographic Situations.—It has been hitherto found only in veins in the copper-mines in Cornwall.

Genus II. URAN-MICA, or URANITE.

One axis. Cleavage pyramidal. Streak green. Hardness = 2 0.—2.5. Sp. gr. =3.1 —3.3.

This genus contains one species, viz. Pyramidal Uranite.

1. Pyramidal Uranite, *Jameson.*—Pyramidaler Uran-Glimmer, *Mohs.* Uran-Glimmer, *Werner.*

Pyramid = 95°, 13′; 144° 56′. The only distinct cleavage is that parallel with the base of the prism.

External Characters.—Chief colours green and yellow. Seldom massive, sometimes in flakes; the massive varieties are disposed in angulo-granular concretions. Frequently crystallized. The secondary forms are the following:

1. Rectangular four-sided table, or short prism. Sometimes elongated. 2. The four-sided table bevelled on the terminal planes, and the bevelling planes set on the lateral planes. 3. The terminal edges of the table truncated, thus forming an eight-sided table. 4. The terminal planes of the four-sided table bevelled; and sometimes the edges of the bevelment truncated. 5. When the bevelling planes of No. 4, increase very much in size, there is formed a very acute double four-sided pyramid, in which the apices are more or less deeply truncated. 6. Sometimes the figure, No. 4. is acuminated on both extremities with four planes, which are set on the lateral planes, and the apices of the acuminations deeply truncated.

Crystals are small and very small, superimposed, and form druses. Terminal planes of the table streaked, but the lateral planes smooth. Externally, it is usually shining and sometimes splendent. Internally shining, approaching to glistening; lustre pearly. Transparent and translucent. Streak green. Sectile. Not flexible. Easily frangible.

Chemical Characters.—It decrepitates violently before the blowpipe on charcoal; loses about 33 *per cent.* by ignition, and acquires a brass-yellow colour.

		Cornwall.
Constit. Parts.—	Oxide of Uranium, with a trace of Oxide of Lead,	74.4
	Oxide of Copper, .	8.2
	Water, . . .	15.4
	Loss, . . .	2. —100

Gregor, in Annals of Phil. vol. v. p. 284.

Geognostic and Geographic Situations.—Occurs in veins in primitive rocks. In Cornwall in tinstone and copper veins that traverse granite and clay-slate.

Werner describes a soft mineral, found along with Uranite, under the name Uran-Ochre. It does not appear to form a distinct species, nor can it be considered as a subspecies of Uranite. It is here placed immediately after Uranite.

* Uran-Ochre, *Jameson.*—Uran-Ocker, *Werner.*

There are two kinds of this mineral, viz. Friable and Indurated.

1. Friable Uran-Ochre, *Jameson.*—Zerreibliche Uranocker, *Werner.*

External Characters.—Colour lemon-yellow, which passes into straw-yellow and sulphur-yellow, and also into orange-yellow. Occurs usually as a coating or efflorescence on pitch-ore, and sometimes small reniform. Is friable, and composed of dull, dusty, and weakly cohering particles. Feels meagre.

Geognostic Situation.—Occurs always on pitch-ore.

2. Indurated Uran-Ochre, *Jameson.*—Feste Uranocker, *Werner.*

External Characters.—Colours are straw-yellow, lemon-yellow, and orange-yellow; and this latter passes into aurora-red and hyacinth-red, and reddish and yellowish brown. Occurs massive, disseminated, and superimposed; and sometimes a tendency to fibrous concretions. Internally glimmering, glistening, and resinous. Fracture imperfect conchoidal. Opaque. Soft and very soft. Rather Sectile. Specific gravity, 3.1500, *La Metherie.*—3.2438, *Haüy.*

Chemical Characters.—According to Klaproth, the yellow varieties are pure oxide of uranium, but the brownish and reddish contain also a little iron.

Geognostic and Geographical Situations.—It is found at Joachimsthal, and Gottesgab in Bohemia, and at Johanngeorgenstadt in Saxony.

Genus III.—COBALT MICA, or RED COBALT.

Kobalt Glimmer, *Mohs.*

Three axes. Cleavage prismatic. Streak red, green. Hardness = 2.5. Sp. gr. = 4.43.

This genus contains one species, viz. Prismatic Red Cobalt.

1. Prismatic Red Cobalt, *Jameson*.—Prismatischer Kobalt Glimmer, *Mohs.*

Prism unknown. Cleavage prismatoidal.

This species is divided into three subspecies, viz. Radiated Red Cobalt, Earthy Red Cobalt, and Slaggy Red Cobalt.

First Subspecies.

Radiated red cobalt, or cobalt-bloom, *Jameson.*—Kobalt-bluthe, *Werner.*

External Characters.—Principal colour red; rarely greenish-grey, and olive-green. Occurs massive, disseminated, often in membranes, small reniform, small botryoidal; also in stellular and scopiform radiated or fibrous concretions, which are sometimes collected into granular concretions; it also occurs crystallized. Crystals generally acicular or capillary, and scopiformly or stellularly aggregated. Externally shining, passing into splendent. Internally shining and glistening, and lustre pearly. Fragments splintery and wedge-shaped. More or less translucent; sometimes translucent on the edges. Colour not changed in the streak. Rather sectile. Easily frangible.

Chemical Characters.—Before the blowpipe it becomes grey, and emits an arsenical odour, and tinges borax glass blue.

Constituent Parts.—	Cobalt, . .	39
	Arsenic Acid, .	38
	Water . .	23— 100

Buckholtz. in J. d. Min. t. 25 p. 158.

Geognostic Situation.—Occurs in veins, in primitive, transition, and secondary rocks, along with various metalliferous compounds.

Geographic Situation.—Occurs in veins in secondary rocks at Alva, in Stirlingshire; in limestone of the coal formation in Linlithgowshire; formerly in small veins in sandstone of the coal formation, along with galena and blende, at Broughton, in Edinburgh; in the Clifton lead-mines near Tyndrum; and at Dolcoath in Cornwall.

Second Subspecies.

Earthy Red Cobalt, or Cobalt-crust. *Jameson.*—Kobold-beschlag, *Werner.*

External Characters.—Colour red. Seldom occurs massive or disseminated, generally in velvety crusts, and also small reniform and botryoidal. Generally friable, and composed of scaly and dusty particles, which are feebly glimmering or dull. The massive varieties have a fine earthy fracture. Fragments indeterminate angular, and blunt edged. Very easily frangible. Very soft or friable. Sectile. Streak shining. Does not soil.

Third Subspecies.

Slaggy Red Cobalt, *Jameson.*—Schlackige Kobaltbluthe, *Hausmann.*

External Characters.—Colours muddy crimson-red, and dark hyacinth-red, which passes into chesnut-brown. Occurs in thin crusts, and sometimes reniform. Externally smooth. Lustre shining and resinous. Fracture conchoidal. Translucent. Soft and brittle.

Geognostic and Geographic Situations.—Occurs in veins along with other cobaltic minerals, in the mine of Sophia, at Wittichen in Furstemberg.

Cobalt Ochre.

The Black, Brown, and Yellow Cobalt Ochres, and other similar minerals, ought to be arranged together, and form a particular order by themselves. In the mean time, we place them beside the Red Cobalt, on account of their being often associated in nature with that mineral.

*I. Black Cobalt Ochre, *Jameson.*—Schwarz Erdkobold, *Werner.*

It is distinguished into Earthy Black Cobalt-ochre, and indurated Black Cobalt-ochre.

a. Earthy Black Cobalt-Ochre, *Jameson.*——Schwarzer Kobold Mulm, *Werner.* Cobalt oxide noire terreux, *Haüy.*

External Characters—Colour intermediate between brownish and blackish-brown. Friable, and composed of dull coarse particles, which soil very little. Streak shining. Meagre to the feel. Light.

Chemical Characters.—Before the blowpipe, it yields a white arsenical vapour; and it colours borax blue.

b. Indurated Black Cobalt-Ochre, *Jameson.* Fester Schwarz Erdkobold, *Werner.*

External Characters—Colour distinct bluish-black. Occurs massive, disseminated, in crusts, small botryoidal, small reniform, fruticose, moss-like, stalactitic, corroded, specular, and with pyradimal impressions. Sometimes it occurs in thin and curved lamellar concretions. Surface feebly glimmering. Fracture fine earthy, sometimes passing into conchoidal. Fragments indeterminate angular, and blunt-edged. Opaque. Streak shining and resinous. Very soft, approaching to soft. Soils feebly. Sectile. Very easily frangible. Specific gravity, 2.019 to 2.425, *Gellert.*—2.200, *Breithaupt.*

Chemical Characters.—Before the blowpipe it yields an arsenical odour, and colours glass of borax smalt-blue.

Constituent Parts.—It is considered as black oxide of cobalt, with arsenic and oxide of iron.

Geognostic Situation.—Both sorts usually occur together, and in the same kind of repository; but the first is the rarest. They are found sometimes in primitive mountains, but most frequently in secondary mountains.

Geographic Situation.—It is found at Alderly Edge, Cheshire, in red sandstone; in slate-clay in the peninsula of Howth near Dublin; at Riegelsdorf in Hessia, and in many other countries on the continent.

Uses.—It is used in the making of smalt, and affords a good blue colour, but not so fine as that obtained from grey cobalt. Of the two kinds of black cobalt, the compact is that which affords the most esteemed blue colour.

II. Brown Cobalt Ochre, *Jameson.*—Brauner Erdkobold, *Werner*

External Characters.—Principal colour brown, grey, and brownish black. Occurs massive, disseminated, and sometimes very much cracked. Internally dull. Fracture fine earthy, approaching to conchoidal in the large. Fragments indeterminate angular, and blunt-edged. Opaque. Streak shining and resinous. Very soft. Sectile. Very easily frangible. Light.

Chemical Characters.—Before the blowpipe it emits an arsenical odour, and communicates a blue colour to borax.

Constituent Parts.—It is considered to be a compound of Brown Ochre of Cobalt, Arsenic, and Oxide of Iron.

Geognostic Situation—It appears to occur principally in secondary mountains, and is generally accompanied with red and black cobalt-ochre, ochry-brown iron stone, and lamellar heavy spar.

Geographic Situation.—It is found at Kamsdorf and Saalfeld in Saxony; Alpirsbach in Wurtemberg; and in the valley of Gistain in Spain.

Uses.—It is used for making smalt, but is not so valuable as the black cobalt.

Observations.—Distinguished from *Umber*, *Bole*, and other minerals of the same description, by its streak and softness.

3. Yellow Cobalt Ochre, *Jameson.*—Gelber Erdkobold, *Werner.* Cobalt arseniaté terreaux argentifere(?) *Haüy*

External Characters.—Colour yellow, which in some varieties is grey and white. Occurs massive, disseminated, corroded, and incrusting. Frequently appears rent in different directions. Internally it is dull. Fracture fine earthy in the small, conchoidal in the large. Fragments indeterminate angular, and blunt-edged. Streak shining. Is soft, passing into friable. Is sectile. Is very easily frangible.

Specific gravity 2.677, *Kirwan*, after having absorbed water.

Chemical Characters.—It emits an arsenical odour before the blowpipe, and colours borax blue. Appears to be the purest of the cobalt ochres. Generally contains a portion of silver.

Geognostic Situation.—Occurs in the same geognostic situation as the preceding, and is almost always associated with earthy red cobalt, and sometimes with radiated red cobalt, nickel-ochre, iron-shot, copper-green, and azure copper.

Geographic Situation.—Occurs at Saalfeld in Thuringia; Kupferberg in Silesia; Wittichen in Furstenberg; and Alpirsbach in Wurtemberg, in Swabia; and Allemont in France.

Use.—Affords a better smalt than the preceding, and, owing to the silver it contains in the countries where it occurs, is also valued as an ore of silver.

Genus IV. ANTIMONY MICA, or WHITE ANTIMONY.

Spiessglass-glimmer, *Mohs.*

Three axes. Cleavage prismatic. Hardness = 1.5—2.0. Sp. gravity = 5.0—5.6.

This genus contains one species, viz. Prismatic Antimony Mica, or White Antimony.

1. Prismatic White Antimony, *Jameson.*—Prismatischer Speissglass-glimmer, *Mohs.* Weiss-spiesglaserz, *Werner.*

Prism unknown. Cleavage prismatic.

External Characters.—Its colours are white and grey. Seldom occurs massive, more frequently disseminated, and in membranes; also in distinct concretions, which are coarse and small granular, and scopiform and stellular radiated. Is often crystallized. The following figures have been observed :—1. Rectangular four-sided prism, bevelled on the extremities; 2. Oblique four-sided prism; 3. Rectangular four-sided table; 4. Six-sided prism; 5. Acicular and capillary crystals. The tables are small and very small, usually adhering by their lateral planes, and sometimes, although seldom, manipularly aggregated, and often intersecting each other, in such a manner as to form cellular groups. The crystals are sometimes smooth, sometimes feebly longitudinally streaked, and splendent. Internally it is shining, and the lustre is intermediate between pearly and adamantine. The fragments are indeterminate angular, or wedge-shaped. Is translucent. Is rather sectile.

Chemical Characters.—Before the blowpipe it melts very easily, and is volatilized in the form of a white vapour.

		Allemont.
Constit. Parts.—Oxide of Antimony	.	86
Oxides of Antimony and Iron		3
Silica	. . . .	8—98

Vauquelin, Hauy, t. iv. p. 274.

Geognostic and Geographic Situations.—It occurs in veins in primitive rocks, and is usually accompanied with the other ores of antimony. At Prizbram, in Bohemia, it occurs along with crystallized galena or lead-glance; and at Allemont, with native antimony, and grey and red antimony. It has also been found in Malaxa in Hungary.

* Antimony Ochre, *Jameson.*—Spiesglanzocker, *Werner.*

External Characters.—Its colour is yellow, grey, and brown. Scarcely occurs massive, and disseminated, generally incrusting crystals of grey antimony. Is dull. Fracture earthy, and sometimes inclines to radiated. Is opaque. Is soft, passing into very soft. Is brittle, and easily frangible.

Chemical Characters.—Before the blowpipe, on charcoal, it becomes white, and evaporates without melting. With borax, it intumesces, and is partly reduced to the metallic state.

Geognostic and Geographic Situations.—It occurs always in veins, and accompanied with grey antimony, and sometimes with red antimony. It is found at Huel Boys, in Endellion, in Cornwall.

Genus V. BIUE IRON, or IRON MICA.

Eisen Glimmer, *Mohs.*

Three axes. Cleavage prismatic. Streak white? Hardness =2.0. Sp. gravity =2.8—3.0.

This genus contains two species, viz. Prismatic Blue Iron.

1. Prismatic Blue Iron.

Prism unknown. Cleavage prismatoidal.

This species is divided into three subspecies, viz. Foliated Blue Iron, Fibrous Blue Iron, and Earthy Blue Iron.

First Subspecies.

Foliated Blue Iron, *Jameson.*—Blättriches Eisenblau, *Hausmann.*

External Characters.—Its colours are blue and green. The secondary forms are the following.

1. Broad rectangular four sided prism, in which the lateral edges are truncated, (the truncating planes are set obliquely on the smaller lateral planes, and are the original planes of the oblique four-sided prism,) flatly bevelled on the extremities; the bevelling planes set obliquely on the broader lateral planes. 2. Eight-sided prism, acuminated with four planes. The crystals are sometimes acicular, and deeply longitudinally streaked. Are small, or middle-sized, and superimposed. Externally shining or splendent. Internally shining, passing into splendent, and pearly, inclining to adamantine. Fragments long tabular, or splintery. Is translucent on the edges, or strongly translucent. Colour paler blue in the streak. Sectile, and easily frangible. Flexible in thin pieces.

	From the Isle of France
Constituent Parts.—Oxide of Iron, .	41.25
Phosphoric Acid,	19 25
Water, . .	31.25
Ironshot Silica,	1.25
Alumina, . .	5.00—98

Fourcroy and Laugier, *in Ann. du Mus.* t. iii. p. 405.

Geographic and Geognostic Situations.—It occurs in Whealkind Mine, in St. Agnes's, in Cornwall; along with iron-pyrites, and magnetic-pyrites, in gneiss, in the Silberberg, at Bodenmais, in Bavaria; and in the department of Allier, in France.

Second Subspecies.

Fibrous Blue Iron, *Jameson.*—Fasriges Eisenblau, *Hausmann.* Fasriges Eisenblau, *Haus.* Hand. b. iii. s. 1076.

External Characters.—Its colour is indigo-blue. Occurs massive, and sometimes intimately connected with hornblende, and in roundish blunt angular pieces; also in delicate fibrous concretions, which are scopiform or promiscuous. Internally glimmering and silky. Opaque. Soft.

Geognostic and Geographic Situations.—*Europe.*—It occurs in transition syenite at Stavern in Norway.—*America.*—In West Greenland.

Third Subspecies.

Earthy Blue Iron, *Jameson.*—Blau Eisenerde, *Werner.* Erdiges Eisenblau, *Hausmann.*

External Characters.—In its original repository it is said to be white, but afterwards becomes indigo-blue, of different degrees of intensity, which sometimes passes into smalt-blue. Is usually friable, sometimes loose, and sometimes cohering. Occurs massive, disseminated, and thinly coating. Its particles are dull and dusty. It soils slightly. Feels fine and meagre. Is rather light.

Chemical Characters.—Communicates to glass of borax a brown colour, which at length becomes dark-yellow. Dissolves rapidly in acids.

	From Eckartsberg.
Constituent Parts.—Oxide of Iron,	47.50
Phosphoric Acid,	32.00
Water .	20.00—99.50

Klaproth, *Beit.* b. iv. s. 122.

Geognostic Situation.—Occurs in nests and beds in clay-beds, also disseminated in bog iron-ore, or incrusting turf and peat.

Geographic Situation.—*Europe.*—On the surface of peat-mosses in several of the Shetland Islands; and in river mud at Toxteth, near Liverpool; Iceland.—*Asia*. Borders of the Lake Baikal in Siberia.—*America*. Along with bog iron-ore in alluvial soil in New Jersey.

Uses.—Is sometimes used as a pigment. Is principally employed in water-colours, because, when mixed with oil, the colour is said to change into black.

Genus VI. GRAPHITE.*

Kohlen Glimmer, *Mohs*.

One axis. Cleavage rhomboidal. Streak black. Hardness=1.0—2 5. Sp. gravity=2.7—3.0.

This genus contains one species, viz. Rhomboidal Graphite.

1. Rhomboidal Graphite, *Jameson*.—Graphit, *Werner*.

Rhomboid unknown. Cleavage axifrangible.

This species is divided into two subspecies, viz. Scaly Graphite, and Compact Graphite.

First Subspecies.

Scaly Graphite.—Schuppiger Graphit, *Werner*.

External Characters.—Colour dark steel-grey, which approaches to light iron-black. Occurs massive, disseminated; in coarse, small, and fine granular concretions; and crystallized. Only secondary form hitherto met with, is the equiangular six-sided table. Internally shining, passing into splendent, and lustre metallic. Fracture scaly foliated. Fragments indeterminate angular, and blunt-edged. Streak shining, even splendent, and lustre metallic. Perfectly sectile. Rather difficultly frangible. Writes and soils. Streak black. Feels very greasy.

Second Subspecies.

Compact Graphite, *Jameson*.—Dichter Graphite, *Werner*.

External Characters.—Colour is nearly the same with the preceding, only rather blacker. Occurs massive and disseminated, also in columnar concretions. Internally it is glimmering, sometimes glistening, and the lustre is metallic. Fracture small and fine grained uneven, which passes into even, and also into large and flat conchoidal; the large is sometimes slaty longitudinal. Fragments indeterminate angular and blunt-edged, and sometimes also tabular. In other characters it agrees with the preceding subspecies.

Chemical Characters.—When heated in a furnace it burns without flame or smoke, and during combustion emits carbonic acid, and leaves a residuum of red oxide of iron.

Constituent Parts.

Berthollet.		Graphite of Pluffier.	
Carbon,	90.0	Carbon,	23
Iron,	9.1—100.00	Iron,	2
		Alumina,	37
		Silica,	38—100

Journal des Mines, N. 12, p. 16.

Geognostic Situation.—Occurs usually in beds, sometimes disseminated, and in imbedded masses, in granite, gneiss, mica-slate, clay-slate, foliated granular limestone, coal and trap formations.

Geographic Situation.—Occurs in imbedded masses, and disseminated in gneiss in Glen Strath Farrar in Inverness-shire; in the coal formation near Cumnock, in Ayrshire, where it is imbedded in greenstone, and in columnar glance-coal. At Borrodale, in Cumberland, it occurs in a bed or beds of very varying thickness, included in a bed of trap, which is subordinate to clay-slate. This trap varies in its nature, being sometimes greenstone, or trap-tuff, in other instances amygdaloid, which is occasionally slaty, and contains agates.

Uses.—The finer kinds are first boiled in oil, and then cut into tables or pencils: the coarser parts, and the refuse of the sawings, are melted with sulphur, and then cast into coarse pencils for carpenters; they are easily distinguished by their sulphureous smell. It is also used for brightening and preserving grates and ovens from rust; and, on account of its greasy quality, for diminishing the friction in machines. Crucibles are made with it, which resist great degrees of heat, and have more tenacity and expansibility than those manufactured with the usual clay mixtures.

Genus VII. MICA.

Talk-glimmer, *Mohs*.

One axis. Cleavage rhomboidal. Streak green, white. Hardness=1.0—1.5. Sp. gravity=2 7—3.0.

This genus contains one species, viz. Rhomboidal Mica.

1. Rhomboidal Mica, *Jameson*.—Rhomboedrischer Talk-glimmer, *Mohs*.

Rhomboid unknown. Cleavage parallel with the terminal planes of the regular six-sided prism.

This species is subdivided into ten subspecies, viz. 1. Mica; 2. Pinite; 3. Lepidolite; 4. Chlorite; 5. Green Earth; 6. Talc; 7. Nacrite; 8. Potstone; 9. Steatite; 10. Figure-stone. *Clay-slate, Whet-slate, Black Chalk, Alum-slate.

First Subspecies.

Mica,† *Jameson*.—Glimmer, *Werner*.

External Characters.—Its most common colours are grey, brown, black, and white, and very rarely peach-blossom red. It occurs massive, and disseminated; also in distinct concretions, which are large, coarse, and small granular, and wedge-shaped prismatic. The following are the secondary forms:

1. Equiangular six-sided prism. 2. Equiangular six-sided table. 3. Equiangular six-sided table, truncated on four of the terminal edges. 4. Equiangular six-sided table, bevelled on the terminal planes, and the edges of the bevelment truncated. 5. Rectangular four-sided table. 6. Rectangular four-sided prism.

Crystals middle-sized and small, seldom large. Tables generally adhere by their terminal planes, seldom by their lateral planes, and form druses. Sometimes arranged in rows, rarely in the rose-form, and seldom intersecting each other. Lateral planes of the tables, and the terminal planes of the prism, smooth and resplendent; terminal planes of the table longitudinally streak-

* *Graphite*, from γραφω, *I write*, on account of its writing quality.

† *Mica*, from the Latin word *mico*, to shine, given to it on account of its lustre.

ed, lateral planes of the prism transversely streaked. Internally generally resplendent, seldom shining, generally pearly, sometimes semimetallic, and in the silver-white variety passing into metallic. Fracture not discernible. Fragments tabular and splintery. Translucent or transparent in thin plates, but rarely in crystals of considerable thickness or length. Sectile. Affords a grey-coloured dull streak. Feels fine and meagre, smooth. Elastic-flexible.

Chemical Characters.—Before the blowpipe, it melts into a greyish-white enamel.

		Black Mica from Siberia.
Constituent Parts.—	Silica,	42 50
	Alumina,	11.50
	Oxide of Iron,	22.00
	Oxide of Manganese,	2.00
	Potash,	10.00
	Magnesia,	9.00
	Loss by heating,	1.00—98.00

Klaproth, B. v. s. 78.

Geognostic Situation.—This mineral occurs as an essential constituent part of granite, gneiss, and mica-slate, and is accidentally intermixed with other rocks, both of the primitive, transition, secondary or flœtz, and alluvial classes.

Geographic Situation.—The rocks in which mica occurs, are so universally distributed, that it is not necessary to enter into any detail of localities.

Uses.—In Siberia, where window-glass is scarce, it is used for windows; also for a similar purpose in Peru, and, I believe, also in New Spain, as it appears that the mineral named *Teculi* by Ulloa, and which is used for that purpose, is a variety of mica. It is also used in lanterns, in place of glass, as it resists the alternations of heat and cold better than that substance. In Russia, it is employed in different kinds of inlaid work. It is sometimes intermixed with the glaze in particular kinds of earthen-ware; the heat which melts the glaze has no effect on the mica; hence it appears dispersed throughout the glaze, like plates or scales of silver or gold, and thus gives to the surface of the ware a very agreeable appearance. Some artists use it in the making of artificial aventurines.

Second Subspecies.

Pinite, *Jameson.*—Pinit, *Werner.* Micarelle, *Kirwan.*

External Characters.—Colour blackish-green, altered on the surface by brown or red iron-ochre into brownish-red. Sometimes iron-shot. Occurs massive, also in distinct concretions, which are thick and thin lamellar, collected into large and coarse granular, and crystallized in the following figures:

1. Equiangular six-sided prism. 2. The preceding figure truncated or bevelled on all the lateral edges. Owing to the number of planes, figures of this description have a cylindrical form. The terminal angles are sometimes truncated.

Crystals seldom middle-sized, generally small. They are imbedded, and frequently intersect each other. Cleavage shining; fracture glistening and glimmering; lustre resinous. Fracture small grained uneven. Fragments blunt-angular, seldom tabular. Opaque; faintly translucent on the edges. Sectile. Easily frangible. Not flexible. Feels somewhat greasy.

Chemical Character.—It is infusible before the blowpipe.

Constituent Parts.—	Silica,	29.50
	Alumina,	63.75
	Oxide of Iron,	6.75—100.00

Klaproth, Jour. des Mines, N. 100. p. 311.

Geognostic and Geographic Situations.—It is found imbedded in the granite of St. Michael's Mount in Cornwall; in porphyry in Ben Gloe and Blair-Gowrie.

Third Subspecies.

Lepidolite, *Jameson.*—Lepidolith, *Werner.*

External Characters.—Colour peach-blossom-red, inclining sometimes to rose-red, sometimes to lilac-blue; passes into pearl-grey, yellowish-grey, and greenish-grey. Occurs massive, and in small granular distinct concretions. Internally its lustre is glistening, passing into shining, and pearly. Fracture coarse splintery. Fragments indeterminate angular and blunt-edged. Feebly translucent. Soft. Rather sectile. Rather easily frangible. Specific gravity, 2.816, *Klaproth.*—2.58, *Karsten.*

Chemical Characters.—Before the blowpipe it intumesces, and melts very easily into a milk-white nearly translucent globule.

Constituent Parts.—	Silica,	54.00
	Alumina,	20.00
	Potash,	18.00
	Fluate of Lime,	4.00
	Manganese,	3.00
	Iron,	1.00—100

Vauquelin Jour. de Min. t. ix. p. 235.

Geognostic and Geographic Situations.—It occurs disseminated, in foliated and granular limestone, at Dalmally, and in other quarters of the Highlands.

Fourth Subspecies.

Chlorite, *Jameson.*—Chlorit, *Werner.*

This subspecies is divided into four kinds, viz. Earthy Chlorite, Common Chlorite, Slaty Chlorite, and Foliated Chlorite.

First Kind.

Earthy Chlorite, *Jameson.*—Erdiger Chlorit, *Karsten.*

External Characters.—Colour green. Occurs massive, desseminated, in crusts, and moss-like, inclosed in adularia and rock-crystal. Glimmering or glistening; lustre pearly. Consists of fine scaly particles, which are more or less cohering, and feel rather greasy. Does not soil. Streak is of a mountain-green colour.

Chemical Characters.—It melts before the blowpipe into a blackish slag.

Constituent Parts.—	Silica,	26.00
	Alumina,	18 50
	Magnesia,	8.00
	Muriate of Soda, or Potash,	2.00
	Oxide of Iron,	43 00
	Loss,	2.50—99.00

Vauquelin, Journ. des Mines, N. 39. p. 167.

Geognostic and Geographic Situations.—It occurs in veins along with common chlorite at Forneth Cottage in Perthshire.

Second Kind.

Common Chlorite, *Jameson.*—Gemeiner Chlorit, *Werner.*

External Characters.—Colour is intermediate between dark blackish-green and leek-green. Occurs massive and disseminated. Lustre glimmering, or glistening; pearly, inclining to resinous. Fracture fine earthy; fine scaly foliated. Fragments blunt-edged. Opaque. Becomes light mountain-green in the streak, with a feeble lustre. Soft. Sectile. Does not adhere to the tongue. Feels somewhat greasy.

Geognostic and Geographic Situations.—Occurs not only disseminated through rocks of different kinds, as granite and mica-slate, but also in beds and veins. It is met with in Arran, Bute, &c.

Third Kind.

Slaty Chlorite or Chlorite-Slate, *Jameson.*—Chlorit-Schiefer, *Werner.* Schiefriger Chlorit, *Karsten.*

External Characters.—Colour intermediate between dark mountain and leek-green; sometimes passes into blackish-green and greenish-black. Occurs massive, and in whole beds. Lustre glistening, sometimes inclining to shining, and intermediate between pearly and resinous. Fracture more or less perfect slaty, seldom straight, generally waved slaty, and sometimes scaly foliated. Fragments tabular. Opaque. Affords a pale mountain-green streak. Sectile; rather easily frangible. Does not adhere to the tongue. Feels slightly greasy.

Geognostic Situation.—Occurs principally in beds, subordinate to clay-slate, and is occasionally associated with potstone and talc-slate.

Geographic Situation.—Occurs in beds, in the clay-slate districts of the Grampians, and other parts of Scotland.

Fourth Kind.

Foliated Chlorite, *Jameson.*—Blättriger Chlorit, *Werner.*

External Characters.—Colour dark blackish-green, which in some rare varieties is dark olive-green. Occurs massive, disseminated, in granular concretions, and crystallized in four-sided prisms, and in six-sided tables. These tables are aggregated together, in such a manner as to form the two following figures:

A. Cylinder terminated by two cones.

B. Two truncated cones, joined base to base.

Crystals generally longitudinally streaked, and are small or middle-sized. Externally glistening, approaching to shining, and resinous; internally shining, and pearly. Fragments indeterminate angular; tabular. Opaque; translucent on the edges; sectile; rather difficultly frangible. Feels rather greasy. Colour lighter in the streak.

Geognostic and Geographic Situations.—It occurs in the Island of Jura, one of the Hebrides, in quartz rock.

Fifth Subspecies.

Green Earth, *Jameson.*—Grünerde, *Werner.*

External Characters.—Colour green. Occurs massive, seldomer disseminated, more frequently in globular and amygdaloidal-shaped pieces, which are sometimes hollow, in crusts lining the vesicular cavities in amygdaloid, or on the surface of agate balls. Internally dull. Fracture earthy, sometimes small grained uneven. Opaque. Feebly glistening in the streak, but without any change of colour. Feels rather greasy. Adheres slightly to the tongue.

Chemical Characters.—Before the blowpipe it is converted into a black vesicular slag.

		From the Veronese.
Constituent Parts.—	Silica,	53.0
	Oxide of Iron	28.0
	Magnesia,	2.0
	Potash,	10.0
	Water,	6.0—99.0

Klaproth, Beit. B. iv. s. 241.

Geognostic Situation.—It occurs principally in the amygdaloidal cavities of amygdaloid, and incrusting the agates found in that rock. It also occasionally colours sandstone, and is disseminated in porphyry.

Geographic Situation.—It is a frequent mineral in the amygdaloid of Scotland; it occurs also in that of England and Ireland.

Uses.—It is used as a pigment in water-painting, and is the *mountain-green* of painters.

Sixth Subspecies.

Talc, *Jameson.*—Talk, *Werner.*

This species is divided into two kinds, viz. Common Talc and Indurated Talc.

First Kind.

Common Talc, *Jameson.*—Gemeiner Talk, *Werner.*

External Characters.—Common colours white and blue. Occurs massive, disseminated, in plates, reniform and botryoidal; in distinct concretions, which are large, coarse and small granular; also narrow or broad and stellular or promiscuous radiated, which are again collected into other concretions, having a wedge-shaped prismatic form. Sometimes crystallized in small six-sided tables, which are in druses. Generally splendent; shining; pearly; semi-metallic. Fragments wedge-shaped, seldom splintery. Translucent; in thin folia transparent. Flexible; not elastic. Sectile. Feels very greasy.

Chemical Characters.—It becomes white before the blow-pipe, and at length, with difficulty affords a small globule of enamel.

Constituent Parts.—	Silica,	61.75
	Magnesia,	30.50
	Potash,	2.75
	Oxide of Iron,	2.50
	Water,	0 25
	Loss,	2.25

Klaproth, Karst. Tab. s. 43.

Geognostic Situation.—It occurs in beds in mica-slate and clay-slate, and in a similar situation in granular limestone and dolomite; also in cotemporaneous veins, in beds of indurated talc, serpentine, and porphyry; and in the reniform external shape in tinstone veins.

Geographic Situation.—It is found in Aberdeenshire, Banffshire, and Perthshire.

Use.—It enters into the composition of the cosmetic named *rouge.*

Second Kind.

Indurated Talc, or Talc Slate, *Jameson.*—Verhärteter Talk, *Werner.*

External Characters.—Colours grey and green. Occurs massive, and rarely in fibrous distinct concretions. Lustre shining, passing to glistening; pearly. Fracture curved slaty, passing into imperfect foliated. Fragments tabular. Strongly translucent on the edges; sometimes feebly translucent. Rather sectile. Rather easily frangible. Not flexible. Feels greasy.

Geognostic Situation.—It occurs in primitive mountains, where it forms beds in clay-slate and serpentine, and is associated with amianthus, chlorite, rhomb-spar, garnet, actynolite, quartz, kyanite and grenatite.

Geographic Situation.—It occurs in Perthshire, Banffshire, and the Shetland islands.

Uses.—It is employed for drawing lines by carpenters, tailors, hat-makers, and glaziers. The lines are not so easily effaced as those made by chalk, and besides remain unaltered under water.

Seventh Subspecies.

Nacrite, *Jameson.*—Nacrite, *Brongniart.* Erdiger Talk, *Werner.*

External Characters.—Colours greenish-white, and greenish-grey. Consists of scaly parts, which are more or less compacted; the most compact varieties have a thick or curved slaty fracture. Strongly glimmering; pearly; inclining to resinous. Friable. Feels very greasy; soils.

Chemical Characters.—It melts easily before the blowpipe.

Constituent Parts.—		
	Alumina,	81.75
	Magnesia,	0.75
	Lime,	4.00
	Potash,	0.50
	Water,	13.50—100.50.

John.

Geognostic and Geographic Situations.—This is a very rare mineral; it occurs in veins with sparry ironstone, galena, iron-pyrites and quartz, in the mining district of Freyberg in Saxony; Gieren in Silesia; and Sylva in Piedmont.

Eighth Subspecies.

Potstone, or Lapis Ollaris, *Jameson.*—Topfstein, *Werner.*

External Characters.—Colour greenish-grey, of different degrees of intensity; darker varieties incline to leek-green, and blackish-green. Occurs massive, and in granular concretions, which are indistinct. Internally glistening, inclining to shining; pearly, inclining to resinous. Fracture curved, and imperfect foliated, which passes into slaty. Fragments indeterminate angular, or slaty. Translucent on the edges. Affords a white-coloured streak. Perfectly sectile. Feels greasy. Rather difficultly frangible.

Chemical Character.—It is infusible before the blowpipe.

Geognostic Situation.—It occurs in thick beds, in primitive clay slate.

Geographic Situation.—It occurs abundantly on the shores of the lake Como in Lombardy, and at Chiavenna in the Valteline; also in different parts in Norway, Sweden, and Finland.

Uses.—When newly extracted from the quarry it is very soft and tenacious, so that it is frequently fashioned into various kinds of culinary vessels, which harden in drying, and are very refractory in the fire.

Ninth Subspecies.

Steatite, or Soapstone, *Jameson.*—Speckstein, *Werner.*

External Characters.—Colours white, reddish-white, and yellow. Sometimes marked with spotted and dendritic greyish-black delineations. Occurs massive, disseminated, in crusts, reniform; and also in the following figures:

1. Equiangular six-sided prism, acutely acuminated on both extremities with six planes. 2. Acute double six-sided pyramid. 3. Rhomboid.

The six-sided prism, and six-sided pyramid, are from rock-crystal, and the rhomboid from calcareous-spar. Both appear to be supposititious, and are small or middle sized, generally imbedded in massive steatite. Lateral planes transversely streaked, and the acuminating planes smooth and shining. Internally dull, and, when glimmering, owing to its being intermixed with foreign parts. Fracture coarse splintery, passing into coarse and fine-grained uneven. Internally dull, seldom feebly glimmering. Fragments indeterminate angular, and blunt-edged. Translucent on the edges. Becomes shining in the streak. Writes but feebly. Very sectile. Rather difficultly frangible. Does not adhere to the tongue. Feels very greasy.

Chemical Characters.—Before the blowpipe, it loses its colour, but is infusible without addition.

Steatite of Monte Ramuzo.

Constituent Parts.—		
	Silica,	44.00
	Magnesia,	44.00
	Alumina,	2.00
	Iron,	7.30
	Manganese,	1.50
	Chrome,	5.00
	Trace of lime and muriatic acid.	——100.80

Vauquelin.

Geognostic Situation.—It occurs frequently in small cotemporaneous veins, that traverse serpentine in all directions; and in angular and other shaped pieces in secondary or floetz-trap rocks. It also occurs in metalliferous veins that traverse primitive rocks.

Geographic Situation.—It occurs in the serpentine of Portsoy and Shetland; in the limestone of Icolmkill; and in the trap-rocks of Fifeshire, the Lothians, Arran, Skye, Canna, and other parts in Scotland. In England, in the serpentine of Cornwall, and at Amlwch in Anglesey.

Uses.—The steatite of Cornwall is used at Worcester, in the manufacture of porcelain. Like fullers earth and indurated talc, it readily absorbs oily and greasy matter, and hence it is used for extracting spots of grease from silk and woollen stuffs. It is also employed in polishing gypsum, serpentine, and marble. When pounded and slightly burnt, it forms the basis of certain cosmetics. It writes readily on glass, in which character it differs from common chalk, which leaves no trace; hence it is used by glaziers, in marking plates of glass before they are cut with diamond.

Tenth Subspecies.

Figurestone, or Agalmatolite†, *Jameson.*—Bildstein, *Werner.* Agalmatolith, *Klaproth.*

† *Agalmatolite,* from the Greek words αγαλμα and λιθος, which signifies *figure-stone,* because it is cut into figures of different kinds in the countries where it is principally found.

External Characters.—Colours grey, green, white, red, and brown. Occurs massive. Internally dull or feebly gimmering. Fracture large and flat conchoidal in the large, splintery in the small, and sometimes imperfect slaty. Fragments indeterminate angular, rather sharp-edged, or imperfect tabular. Translucent, sometimes only on the edges. Becomes feebly resinous in the streak. Immediate between sectile and brittle. Feels rather greasy.

Chemical Characters.—It is infusible before the blowpipe.

		Chinese Figurestone.
Constit. Parts	—Silica,	35 00
	Alumina,	29.00
	Lime,	2.00
	Potash,	7.00
	Iron,	1.00
	Water,	5.00—99.00—*Vauquelin.*

Geographic Situation.—It occurs in China and at Nagyag in Transylvania, but the geognostic situations are unknown.

Uses.—This mineral, owing to its softness, can easily be fashioned into various shapes with the knife: hence, in China, where it frequently occurs, it is cut into human figures, also into pagodas, cups, snuff-boxes, &c.

* Clay Slate*. *Jameson.*—Thonschiefer, *Werner.*

External Characters.—Colours yellowish, ash, smoke bluish, pearl, and greenish grey; from greenish-grey it passes into a colour intermediate between leek-green and blackish-green; from dark smoke-grey into greyish-black and bluish-black; and from pearl-grey into brownish-red† and cherry-red. Sometimes spotted, striped, or flamed. Occurs massive. Lustre pearly, glistening, or glimmering. Fracture more or less perfect slaty; some varieties approach to foliated, others to compact. The slaty is either straight, or undulating curved, and the latter has a twofold obliquely intersecting cleavage. Fragments generally tabular, seldom long splintery or trapezoidal. Is opaque. Affords a greyish-white dull streak. Sectile, and easily split. Feels rather greasy. Specific gravity, 2.661, *Kirwan.* 2.706 *Karsten.*

Chemical Characters.—It is fusible into a slag before the blowpipe.

Constituent Parts.	—Silica,	48.6
	Alumina,	23.5
	Magnesia,	1.6
	Peroxide of Iron,	11.3
	Oxide of Manganese,	0.5
	Potash,	4 7
	Carbon,	0.3
	Sulphur,	0.1
	Water, and Volatile Matter,	7.6
	Loss,	1.8—100
		Daubuisson.

Geognostic Situation.—It occurs in primitive and transition mountains.

Geographic Situation.—It is a very generally distributed rock throughout the mountainous regions in the different quarters of the globe. It abounds in many of the Highland districts in Great Britain and Ireland, and in several of the smaller islands that lie near their coasts.

Use.—It is principally used for roofing houses.

* Whet-Slate, *Jameson.*—Wetzschiefer, *Werner.*

External Characters.—Most common colour greenish-grey; it is found also mountain, asparagus, olive and oil green. Occurs massive. Internally feebly glimmering. Fracture in the large is straight slaty; in the small, splintery. Fragments tabular. Translucent on the edges. Streak greyish-white. Soft in a low degree. Feels rather greasy. Specific gravity 2.722, *Karsten.*

Geognostic Situation.—It occurs in beds in primitive and transition clay-slate.

Geographic Situation.—Very fine varieties are brought from Turkey.

Uses.—When cut and polished, it is used for sharpening iron and steel instruments. For these purposes, it is necessary that it contain no intermixed hard minerals, such as quartz. The light-green coloured varieties, from the Levant, are the most highly prized: those from Bohemia are also much esteemed in commerce. The Levant whet-slate is brought in masses to Marseilles, and is there cut into pieces of various sizes. It is ground by means of sand or sandstone, and polished with pumice and tripoli. These whet-stones, or *hones*, as they are called, ought to be kept in damp and cool places; for when much exposed to the sun, they become too hard and dry for many purposes.

The powder of whet slate is used for cutting and polishing metals, and is by artists considered as a variety of emery.

Drawing-Slate, or Black Chalk, *Jameson.*—Zeichenschiefer, *Werner.*

External Characters.—Colour intermediate between bluish and greyish black, rather more inclining to the latter. Massive. Lustre of the principal fracture glimmering. Cross fracture dull. Principal fracture slaty, generally straight, sometimes curved; cross fracture fine earthy. Fragments partly tabular, partly long splintery. Opaque. Soils slightly, and writes. Retains its colour in the streak, and becomes glistening. Very soft. Sectile. Easily frangible. Adheres slightly to the tongue. Feels fine, but meagre. Specific gravity, 2.110. *Kirwan.*—2.111, *Karsten.*

Chemical Character.—Infusible.

Geognostic Situation.—Occurs in beds in primitive and transition clay-slate; also in secondary or flœtz formations.

Geographic Situations.—Found at Marvilla in Spain, Brittany in France, and in Italy; also in Germany, as in the mountains of Bareuth; and in the coal formation in Scotland.

Uses.—Used for drawing, and also as a black colour in painting.

* Alum Slate.—Alum slate is divided into two kinds, viz. common alum slate, and glossy alum slate.

First Kind.

Common Alum Slate, *Jameson.*—Gemeiner Alaunschiefer, *Werner.*

External Characters.—Colour intermediate between bluish and iron black. Massive, and sometimes in roundish balls, which are imbedded in the massive va-

* Clay-slate, whet-slate, black chalk, and alum-slate, are placed immediately after the subspecies of Rhomboidal Mica, on account of their affinity with it.

† Houses roofed with the red variety of clay-slate appear as if covered with copper.

rieties. Lustre more or less glimmering. Fracture nearly perfect straight slaty. Fragments tabular. Opaque. Does not soil. Retains its colour in the streak, but becomes glistening. Intermediate between soft and semihard. Easily frangible, and rather brittle. Specific gravity 2.384, *Kirwan.*

Second Kind.

Glossy Alum Slate, *Jameson.*—Glänzender Alaunschiefer, *Werner*

External Characters.—Colour intermediate between bluish and iron black, and it sometimes exhibits on the surface of fissures the pavonine, columbine, or temper-steel tarnish. Occurs massive. Lustre semi-metallic and splendent, shining, or glistening, on the principal fracture, and glimmering or dull on the cross fracture. Principal fracture is generally undulating curved and short slaty; seldom inclines to straight slaty. Cross fracture earthy. Fragments tabular, and these run into wedge-shaped fragments. Specific gravity 2.588, 2.339, *Kirwan.*

In all the other characters it agrees with the preceding subspecies.

Geognostic Situation.—Both subspecies agree in geognostic situation: they occur in primitive, and also in transition clay slate, and more rarely in veins traversing these rocks. Some varieties of alum slate have been observed associated with secondary rocks.

Geographic Situation.—It occurs along with greywacke and greywacke slate in the vicinity of Moffat, in Dumfriesshire; in the transition districts of Lanarkshire, particularly in the neighbourhood of Lead Hills; and near the Ferry-town of Cree in Galloway.*

Use.—This mineral, when roasted and lixiviated, affords alum.

The following minerals are placed immediately after the genus Mica, on account of the general affinity to it. Their present situation is not to be considered as fixed, but only temporary.

* 1. Native Magnesia; 2. Magnesite; 3. Meerschaum,
** 4. Nephrite; 5 Serpentine; 6. Fuller's Earth.

1. Native Magnesia.—*Jameson* and *Bruce.*

External Characters.—Colour snow white, passing into greenish white. Occurs massive, and in granular and prismatic concretions. Lustre pearly. Semi-transparent in the mass, transparent in single folia. Soft, and somewhat elastic. Adheres slightly to the tongue. Specific gravity 2.13.

Chemical Characters.—Before the blowpipe it becomes opaque and friable, and loses weight. Soluble in sulphuric, nitric, and muriatic acids.

Constituent Parts.—	Magnesia	70
	Water of crystallization,	30—100

Bruce, American Min. Jour. vol. i. p. 30.

Geognostic and Geographic Situations.—Occurs in small veins in serpentine, at Hoboken in New-Jersey.

2. Magnesite, *Jameson.*—Reine oder Natürliche Talkerde *Werner.*

External Characters.—Colours grey and white. Marked with yellowish and ash-grey spots, and also with bluish-grey dots, and dendritic delineations. Occurs massive, tuberose, reniform, and in a shape intermediate between vesicular and perforated; walls of vesicles rough and uneven. Has a rough surface. Internally dull. Fracture large and flat conchoidal, which passes into fine earthy. Fragments rather sharp-edged. Nearly opaque. Scratched by fluor-spar, but it scratches calcareous-spar. Adheres pretty strongly to the tongue. Feels rather meagre. Dull in the streak. Rather easily frangible. Specific gravity, 2.881, *Haberle.*

Chemical Characters.—Infusible; but before the blowpipe it becomes so hard as to scratch glass.

Constituent Parts.—	Magnesia,	45.42
	Carbonic acid,	47 00
	Silica,	4.50
	Alumina,	0.50
	Ferruginous Manganese,	0.50
	Lime,	0.08
	Water,	2.00—*Bucholz.*

Geognostic and Geographic Situations.—Found at Hrubschitz in Moravia, in serpentine rocks, along with meerschaum, common and earthy talc, mountain cork, and rhomb spar.

3. Meerschaum,† *Jameson.*—Meerschaum, *Werner.*

External Characters.—Colours yellowish and greyish-white, seldom snow-white. Occurs massive. Internally dull. Fracture fine earthy, passing on the one side into flat conchoidal, on the other into even. Fragments indeterminate angular, and not particularly sharp-edged. Opaque, rarely translucent on the edges. Becomes slightly shining in the streak. Does not soil. Very soft. Sectile. Rather difficultly frangible. Adheres strongly to the tongue. Feels rather greasy. Specific gravity, 1.209, *Karsten.*—1.600, *Klaproth.*—0.988, 1.279, *Breithaupt.*

Chemical Character.—Before the blowpipe it melts on the edges into a white enamel.

Constituent Parts.—	Silica, . .	41.50
	Magnesia, .	18.25
	Lime . .	0.50
	Water and carbonic acid, .	39.00—98.25

Klaproth, Beit. b. ii. s. 172.

Geognostic and Geographic Situations.—It occurs in veins in the serpentine of Cornwall; in serpentine, at Hrubschitz in Moravia; at Vallecas, near Madrid in Spain, also in serpentine. It is dug at Sebastopol and Kaffa, in the Crimea; and near Thebes in Greece.

Asia.—It occurs in beds immediately under the soil, at Kittisch and Bursa in Natolia; and in the mountains of Eskischehir, also in Natolia, where from 600 to 700 men are employed in digging meerschaum.

Uses.—When first dug from the earth, it is soft and greasy. It lathers with water like soap; hence it is used by some nations, as by the Tartars, for washing. In Turkey, it is made into tobacco-pipes.

4. Nephrite, *Jameson.*—Nephrit, *Werner.*

Of this mineral there are two kinds, viz. Common Nephrite and Axestone

a. Common Nephrite *Jameson*.—Gemeiner Nephrit, *Werner* F[illegible] N[illegible] *Saussure*

External Characters.—Colour leek-green, of various

† *Meerschaum*, in German, signifies *sea-froth*, and is by some philologists alleged to have been applied to this mineral on account of its general aspect and lightness; while others derive it from the Natolian word *myrsen.*

degrees of intensity, sometimes passes into mountain-green, greenish-grey, and greenish-white. Occurs massive, in blunt-edged pieces, and rolled pieces. Internally dull or glimmering, owing to intermixed talc and asbestus. Fracture coarse-splintery, and the splinters are greenish-white. Fragments indeterminate angular, and rather sharp-edged. Strongly translucent. Nearly as hard as rock-crystal. Difficultly frangible. Feels rather greasy. Rather brittle. Specific gravity, 2.962, Oriental, according to *Karsten*.

Chemical Characters.—Before the blowpipe, it melts into a white enamel.

Constituent Parts.—Silica,	.	50.50
Magnesia,	.	31.00
Alumina,	.	10.00
Iron, .	.	5.50
Chrome,	.	0.05
Water,	.	2.75—*Karsten.*

Geognostic and Geographic Situations.—*Europe.*—In Switzerland, nephrite occurs in granite and gneiss; in the Hartz, in veins that traverse primitive greenstone; and in rolled masses near Leipsic in Saxony.—*Asia.*—The most beautiful varieties of this mineral are brought from Persia and Egypt, from the mines of Seminowski, near Kolyvan in Siberia; and from China.—*America.*—It is found on the banks of the river of Amazons, and near Tlascala in Mexico.

Uses.—Nephrite, when cut and polished, has always an oily and muddy aspect, yet it is prized as an ornamental stone. The Turks cut it into handles for sabres and daggers. Artists sometimes engrave figures of different kinds on it; and it is said to be highly esteemed as a talisman by the savage tribes of the countries where it is found. It was formerly believed to be useful in alleviating or preventing nephritic complaints: hence it has been called *Nephritic Stone.*

b. Axestone, *Jameson.*—Beilstein, *Werner.*—Panamustein, *Blumenbach.*

External Characters.—Colour intermediate between grass-green and leek-green, passes into mountain-green, oil-green, and greenish-grey. Occurs massive. Internally its lustre is strongly glimmering, inclining to glistening. Fracture slaty in the great, and more or less distinctly splintery in the small. Fragments tabular. Translucent, or only strongly translucent on the edges. Semihard, approaching to hard. Softer than common nephrite. Rather difficultly frangible. Specific gravity, 3.008.

Geographic Situation.—It occurs in New Zealand, and several of the Islands in the South Sea. Also in Saxony; and at Gothaab in Greenland, in primitive rocks.

Uses.—It is used by the natives of New Zealand, and other islanders in the South Sea, for hatchets and ear-drops.

5. Serpentine, *Jameson.*—Serpentin, *Werner.*

There are two kinds of this mineral, viz. Common Serpentine, and Precious Serpentine.

a. Common Serpentine, *Jameson.*—Gemeiner Serpentin, *Werner.*

External Characters.—Its colours are green, black, yellow, red. The colours are either uniform, or veined, spotted, dotted, and clouded; and frequently several of these delineations occur together. Occurs massive. Internally it is dull, or glimmering, owing to intermixed foreign parts. Fracture small and fine splintery, sometimes small and fine-grained uneven, which sometimes passes into even; and it is occasionally large, and flat conchoidal. Fragments rather sharp-edged. Translucent on the edges, or opaque. Soft. It does not yield to the nail, but is scratched by calcareous-spar. Rather sectile. Rather difficultly frangible. Feels somewhat greasy. Specific gravity, 2.560, 2.604, *Breithaupt.*

Physical Characters.—Some varieties of serpentine not only move the magnetic needle, but even possess magnetic poles.

Chemical Characters.—It is infusible before the blowpipe, but on exposure to a higher temperature, it melts with difficulty into an enamel.

Constituent Parts.—Silica,	.	.	32.00
Magnesia,	.	.	37.24
Alumina,	.	.	0.50
Lime,	.	.	10.60
Iron,	.	.	0.66
Volatile matter, and Carbonic acid,	.	.	14.16

Hisinger, Afhandlingar, i. Fysik, iii. p. 303.

Geognostic Situation.—Serpentine occurs in primitive, transition, and secondary rocks.

Geographic Situation.—In Scotland, it occurs in the islands of Unst and Fetlar, in Shetland; Isle of Glass in the Hebrides; at Portsoy in Banffshire; near Drimnadrochit, and the town of Inverness, in Inverness-shire; at the Bridge of Cortachie in Forfarshire; and between Ballantrae and Girvan, in Ayrshire. It abounds in some districts in Cornwall in England; and it occurs at Cloghan Lee, on the west coast of Ireland, in the county of Donnegal.

Uses.—As it is soft and sectile, and takes a good polish, it is cut and turned into vessels and ornaments of various kinds.

b. Precious serpentine, *Jameson.*—Edler Serpentin, *Werner.*

This mineral is divided into two sub-kinds, viz. Splintery Precious Serpentine, and Conchoidal Precious Serpentine.

α. Splintery precious serpentine, *Jameson.*—Edler Splittriger Serpentin, *Werner.*

External Characters.—Colour dark leek-green. Occurs massive. Internally it is feebly glimmering. Fracture coarse and long splintery, and sometimes inclines to slaty in the large. Fragments rather sharp-edged. Feebly translucent. Soft, passing into semihard. Specific gravity, 2 704, *Breithaupt.* In other characters it agrees with Common Serpentine.

Geognostic and Geographic Situations.—It occurs in the Island of Corsica, and in Bareuth.

Use.—In Corsica, it is cut into snuff-boxes, and other similar articles.

β. Conchoidal precious serpentine, *Jameson.*—Edler Muschlicher Serpentin, *Werner.*

External Characters.—Colour leek green, which sometimes passes into blackish-green; seldom into Pistachio-green, siskin-green, and oil green. Occurs massive, and disseminated. Lustre glistening, passing into glimmering, and is resinous. Fracture flat conchoidal. Fragments sharp-edged. Translucent, but only translucent on the edges in the dark varieties. Intermediate between soft and semi-hard. Specific gravity, 2.561, 2.643, *Breithaupt*. In other characters it agrees with the foregoing.

Constituent Parts.—	Silica,	42.50
	Magnesia,	38.63
	Lime,	0.25
	Alumina,	1.00
	Oxide of Iron,	1.50
	Oxide of Manganese,	0.62
	Oxide of Chrome,	0.25
	Water,	15.20

John, Chem. Untersuchungen, b. ii. s. 218.

Geognostic Situation.—It generally occurs intermixed with foliated granular limestone in beds subordinate to gneiss, mica-slate, and other primitive rocks. It sometimes occurs in cotemporaneous masses in common serpentine, and then it occasionally contains scales of mica.

Geographic Situation.—It occurs at Portsoy in Banffshire, and in the Shetland Islands; in the island of Holyhead.

Uses.—It receives a finer polish than common serpentine, and was much used by the ancients for pillars and other similar ornamental purposes. At present it is also in great esteem as an ornamental stone.

6. Fuller's earth, *Jameson.*—Walkerde. *Werner.*

External Characters.—Colours white, grey, and green. Some varieties exhibit clouded and striped-coloured delineations. Occurs massive. Dull. Fracture coarse and fine-grained uneven; some varieties are large conchoidal; and others incline to slaty. Fragments blunt-edged, and occasionally incline to slaty. Opaque; but when it inclines to steatite it is translucent on the edges. Becomes shining and resinous in the streak. Very soft, sometimes nearly friable. Sectile. Scarcely adheres to the tongue. Feels greasy. Specific gravity, 1.72, *Karsten.*—1.198, *Hoffmann.*—2.198, *Breithaupt.*

Chemical Characters.—It falls into powder in water, without the crackling noise which accompanies the disintegration of bole. It melts into a brown spongy scoria before the blowpipe.

		Fullers' earth of Ryegate.
Constituent Parts.—	Silica,	53.00
	Alumina,	10.00
	Magnesia,	1.25
	Lime,	0.50
	Muriate of Soda,	0.10
	Trace of Potash,	
	Oxide of Iron,	9.75
	Water,	24.00—98.60

Klaproth, Beit. b. iv. s. 338.

Geognostic and Geographic Situations.—In England it occurs in beds sometimes below, sometimes above the chalk formation; at Rosswein, in Upper Saxony, under strata of greenstone-slate; and in different places in Austria, Bavaria, and Moravia, it is found immediately under the soil.

Uses.—This mineral was employed by the ancients for cleaning woollen, and also linen cloth, and they named it *Terra Fullonum*, and *Creta Fullonum;* hence the name *Fuller's Earth.* The *Morochtus* of Dioscorides, which he celebrates on account of its remarkable saponaceous properties, is conjectured to have been a variety of fuller's earth.

Genus VIII. PEARL MICA.

One axis. Cleavage rhomboidal. Streak white. Hardness=3.5. Sp. gravity=3.0.—3.1.

1. Rhomboidal.

Rhomboid unknown. Cleavage parallel with the terminal planes of the regular six-sided prism.

Order VI. SPAR.

No metallic lustre. No adamantine lustre. Streak white. Hardness ranges from 3.5 to 7.0; if above 6, there are single distinct cleavages. Specific gravity ranges from 2.0 to 3.7; if 2.4 and less, it is not amorphous.*

Genus IX. SCHILLER-SPAR.

Schiller Spath, *Mohs.*

Three axes. Cleavage prismatic. Pearly lustre on single cleavages. If common pearly lustre, the specific gravity=3.2 and less, the hardness=5.5 and less, and colour green. Hardness ranges from 4 to 6. Sp. gravity from 3.0 to 3.4.

This genus contains four species, viz. 1. Prismatic, or Green Diallage, 2. Slaty or Common Schiller-spar, 3. Labrador, or Hyperstene, 4. Straight, or Anthophylite.

1. Prismatic Schiller-Spar, or Green Diallage, *Jameson.*—Prismatische Schiller Spath, *Mohs.*—Diallage Verte, *Haüy.*—Korniger Strahlstein, *Werner.*

Prism unknown. Cleavage prismatoidal. Common pearly lustre. Hardness=4.5,—5.5 Sp. gravity=3.0—3.2.

External Characters.—Colour green. Occurs massive and disseminated. Internally shining, glistening, and pearly. Fragments indeterminate angular, and rather sharp-edged. Translucent on the edges, sometimes passing into translucent. Brittle.

Chemical Characters.—It melts before the blowpipe into a grey or greenish enamel.

Constituent Parts.	Silica	50.0
	Alumina	11.0
	Magnesia	6.0
	Lime	13.0
	Oxide of iron,	5.3
	Oxide of Copper	1.5
	Oxide of Chrome	7.5—94.3

Vauquelin, An. d. Chimie, No. 88.

Geognostic and Geographic Situations.—It occurs in the island of Corsica, along with Saussurite; and with the same mineral in Mont Rosa in Switzerland, and at La Rivera, in the Valley of Susa in Piedmont.

Uses.—The compound of green diallage and Saussurite, named *Gabbro*, by the Italians, *Euphotide*, by the French, and by artists, *Verde di Corsica duro*, when cut and polished, has a beautiful appearance, and is much prized as an ornamental stone. It is cut into snuff-boxes, ring-stones, for in-laid work and other similar purposes.

* The cleavage not given, therefore the characters of this order are incomplete.

2. Slaty Schiller-Spar, *Jameson.*—Schiefer Shiller-Spath, *Mohs.*

Prism nearly 100°. Cleavage prismatoidal. Metallic-like pearly lustre. Hardness = 4.0, 5.0. Sp. gravity = 3.0, 3.3.

This species contains two subspecies, viz. Bronzite and Common schiller-spar.

First Subspecies.

Bronzite, *Jameson.*—Blättriger Anthophyllit, *Werner.*—Diallage metalloide fibro-laminaire, *Hauy.*

External Characters.—Colours brown and grey. Occurs massive, and in coarse and small granular distinct concretions. Internally shining, and the lustre is metallic-pearly. Fragments indeterminate angular and blunt-edged. Translucent on the edges, sometimes approaching to translucent. Affords a white streak. Difficultly frangible.

Chemical Characters.—It is infusible before the blowpipe.

Constituent Parts.		
	Silica,	60.00
	Magnesia	27.50
	Iron	10.50
	Water	0.50—98.50

Klaproth. Beit. b. v. s. 34.

Geognostic and Geographic Situations.—It occurs in greenstone in the island of Skye; in large masses in a bed of serpentine near Kraubat in Upper Stiria, &c.

Second Subspecies.

Common schiller-spar, *Jameson.*—Schillerstein, *Werner.*—Diallage metalloide laminaire, *Hauy.*

External Characters.—Colours green, grey, and brown. Seldom occurs massive, generally disseminated, and sometimes in granular distinct concretions. Internally shining and splendent, the lustre pearly, or metallic-pearly. Fragments indeterminate angular or tabular. Faintly translucent on the edges, or opaque. Streak greenish-grey, and dull. Easily frangible, and slightly inclining to sectile.

Geognostic and Geographic Situations.—It occur simbedded in serpentine, in Fetlar, and Unst in Shetland, and at Portsoy in Banffshire; in the greenstone rocks of the island of Skye; also in the greenstone rocks of Fifeshire; in the porphyritic rock of the Calton Hill, and the trap-rocks of Craig Lockhart, near Edinburgh.

3. Labrador Schiller-spar, or Hyperstene. *Jameson.*—Labradorische Schiller-Spath, *Mohs.*—Hypestene, *Hauy.*

Prism nearly 100. Cleavage prismatoidal. Metallic-like pearly lustre. Hardness = 6.0. Sp. gravity = 3.3, — 3.4.

External Characters.—Its colour is intermediate between greyish and greenish-black, nearly copper-red on the cleavage, and brownish-black, or blackish-brown on the fracture surface. Occurs massive, disseminated, also in thin curved lamellar concretions, which are collected into coarse granular. On the cleavage, the lustre shining and glistening, and metallic-pearly, on the fracture glimmering and pearly Fragments indeterminate, angular, or rhomboidal. Opaque, feebly translucent on the edges. Greenish-grey in the streak. Brittle, rather easily frangible.

Chemical Character.—It is infusible before the blowpipe.

Constituent Parts.		
	Silica	54.25
	Magnesia	14.00
	Alumina,	2.25
	Lime	1.50
	Oxide of Iron,	24.50
	Water,	1.00
	Oxide of Manganese, a trace.	—97.50

Klaproth, Beit. b. v. s. 40.

Geognostic and Geographic Situations.—It was first discovered on the coast of Labrador, and afterwards in the island of Skye, and near to Portsoy.

Uses.—When cut and polished, it has a beautiful copper-red colour, and metallic pearly lustre, and is made into ring-stones and brooches.

4. Straight Schiller-Spar, or Anthophyllite,* *Jameson.*—Gerader Schiller-Spath, *Mohs.* Anthophyllith, *Shumacher.* Strahliger Anthophyllit, *Werner.*

Prism nearly 106°. Cleavage in the direction of a rectangular prism. The lustre nearly metallic pearly. Hardness = 5.0, 5.5. Sp. gravity = 3.0, 3.3.

External Characters.—Colour intermediate between dark yellowish-grey and clove-brown. It generally occurs massive; also in narrow or broad prismatic distinct concretions, which are scopiform or promiscuous, and in which the surface is streaked. Rarely crystallized, in reed-like, very oblique four-sided prisms. Surface of the crystals longitudinally streaked. Lustre shining and glistening, and metallic-pearly. Fragments wedge-shaped and splintery; and sometimes rhomboidal. Translucent on the edges, or translucent.

Chemical Characters.—It becomes dark greenish-black before the blowpipe, but is infusible.

Constituent Parts.		
	Silica	56.00
	Alumina,	13.30
	Magnesia,	14.00
	Lime,	3.33
	Iron,	6.00
	Oxide of Manganese,	3.00
	Water,	1.43

John, Chem. Untersuchungen, 1. s. 200, 201.

Geognostic and Geographic Situations.—It occurs in beds in mica-slate at Kongsberg, in Norway, along with common hornblende, mica, and asbestous-tremolite; at Modum cobalt mines, also in Norway, along with common hornblende, cobalt-glance, and copper-pyrites.

Genus II. KYANITE.†

Disthene Spath, *Mohs.*

Three axes. Cleavage prismatic. In the most perfect cleavages, the hardness is = 5; on the angles it is = 7. Sp. gr. = 3.5.—3.7.

This genus contains one species, viz. Prismatic Kyanite.

1. Prismatic Kyanite, *Jameson.*—Prismatischer Disthene Spath, *Mohs.* Kyanite, *Werner.*

Prism = 102° 50′. Cleavage prismatoidal.

External Characters.—Colours blue, bluish-grey,

* This mineral is named *Anthophyllite* on account of the similarity of its colour with that of the anthophyllum.

† *Kyanite*, from the Greek word κυανος, *sky-blue*, a frequent colour of this mineral.

white, sky-blue, celandine-green, and greenish-grey. The varieties are often marked with blue-coloured flame delineations. Occurs massive and disseminated; also in distinct concretions, which are large and longish angulo-granular, and also wedge-shaped prismatic, which are straight or curved, and sometimes disposed in scopiform or stellular directions. It is sometimes regularly crystallized.

1. Oblique four-sided prism, truncated on the two opposite acute lateral edges. 2. Preceding figure, in which all the lateral edges are truncated. 3. Twin-crystal: it may be considered as two flat four-sided prisms joined together by their broader lateral planes.

The narrow lateral planes are longitudinally streaked, and glistening; the broad are smooth, or delicately transversely streaked and splendent. Crystals middle-sized, small, and very small; are singly imbedded, or intersect one another. Lustre splendent and pearly. Fragments splintery, or imperfectly rhomboidal. Massive varieties translucent. Crystals in general transparent. Rather brittle. Easily frangible.

Chemical Character.—It is infusible before the blowpipe.

Constit. Parts.	Silica,	43.00	
	Alumina,	55.50	
	Iron,	0.50	
	Trace of Potash.		——99.00

Klaproth. Beit. b. v. s. 10.

Geognostic Situation.—It has been hitherto found only in primitive mountains, where it occurs in compact granite, mica-slate, and talc-slate, accompanied with several other minerals.

Geographic Situation.—It occurs in primitive rocks near Banchory in Aberdeenshire, and Boharm, in Banffshire; in mica-slate near Sandlodge, in Mainland, the largest of the Shetland Islands.

Uses.—In India it is cut and polished, and sold as an inferior kind of sapphire.

Genus III. SPODUMENE.†

Three axes. Cleavage prismatic. Three cleavages parallel with the axes, nearly of equal perfection. Hardness = 6. Sp. gr. = 3.0.—3.1.

This genus contains but one species, viz. Prismatic Spodumene.

1. Prismatic Spodumene, *Jameson*.—Prismatischer Triphan Spath, *Mohs*. Triphane, *Hauy*.

Prism nearly = 100°. Cleavage three-fold; two of the cleavages parallel with the lateral planes, and a third with the shorter diagonal of the basis of the prism.

External Characters.—Colour intermediate between greenish-white and mountain-grey, and sometimes passes into oil-green. Occurs massive, disseminated, and in large and coarse granular concretions. Cleavage shining. Fracture glistening. Lustre pearly. Fracture fine-grained uneven. Translucent. Uncommonly easily frangible.

Chemical Characters.—Before the blowpipe, it first separates into small golden yellow coloured folia; and if the heat is continued, they melt into a greenish-white coloured glass.

Constit. Parts.	Silica,	64.4	
	Alumina,	24.4	
	Lime,	3.0	
	Potash,	5 0	
	Oxide of Iron,	2.2	——99.0‡

Vauquelin, Hauy's Tabl. p. 168.

Geognostic and Geographic Situations.—This mineral, which occurs in prismatic rocks, was first discovered in Sudermanland, in Sweden, and afterwards in Ireland, and in other countries.

Genus IV. PREHNITE.

Prehn Spath, *Mohs*.

Three axes. Cleavage axifrangible. Hardness = 6.0—7.0. Specific gr. = 2.8—3.0. Not blue.

This genus contains one species, viz. Prismatic Prehnite.

1. Prismatic Prehnite, *Jameson*.—Prismatischer Prehn Spath, *Mohs*. Prehnite, *Werner*.

Prism = 103°. Cleavage axifrangible.

This species is divided into two subspecies, viz. Foliated Prehnite, and Fibrous Prehnite.

First Subspecies.

Foliated Prehnite, *Jameson*.—Blätriger Prehnite, *Werner*.

External Characters.—Colours green, white, and grey. Occurs massive, and in distinct concretions, which are large, coarse, and fine angulo-granular, and also thick and wedge-shaped prismatic. Sometimes crystallized. The following are some of the secondary forms which the species assumes:

1. Oblique four-sided table, sometimes truncated either on all its terminal edges, or only on the acute edges. When the truncations on the edges increase very much, there is formed, 2. An irregular eight-sided table. When the truncations on all the acute edges increase considerably, there is formed, 3. An irregular six-sided table. When these truncating planes increase in magnitude, and when the table at the same time becomes thicker, and the obtuse edges are slightly truncated, there is formed, 4. A broad rectangular four-sided prism, rather flatly bevelled on the extremities, in which the bevelling planes are set on the smaller lateral planes, and the edge of the bevelment is slightly truncated. Externally crystals almost always shining. Internally shining, or glistening, and pearly. Fracture fine-grained uneven. Alternates from translucent, through semi-transparent into transparent. Rather easily frangible.

Chemical Characters.—It intumesces before the blowpipe, and melts into a pale green or yellow, or greenish-black frothy glass, but does not gelatinate with acids.

Physical Characters.—According to the observations of M. De Dree, it becomes electric by heating.

Constituent Parts.—	Silica,	48
	Alumina,	24
	Lime,	23
	Oxide of Iron,	4—99

Vauquelin.

Geognostic and Geographic Situations.—It occurs in veins in primitive and secondary rocks, in France, Tyrol, Greenland, and Cape of Good Hope.

† On exposure to the blowpipe, it first separates into golden-coloured scales, and then into a kind of powder or ash: hence the name *Spodumene*, from ἀποδόω, *I change into ash*, or σποδος, *ashes*.

‡ According to some analyses, it contains 8 *per cent.* of a new alkali named *lithina*.

SECOND SUBSPECIES.

FIBROUS PREHNITE, *Jameson*.—Fasriger Prehnite, *Werner*.

External Characters.—Colours green and greenish-white. Occurs massive, reniform, in straight scopiform and stellular fibrous and radiated distinct concretions, which are collected into large and coarse angulo-granular concretions; also crystallized in acicular four-sided prisms. Internally glistening; lustre pearly. Translucent. Easily frangible.

Chemical Character.—Before the blowpipe it melts into a vesicular enamel.

Physical Character.—It becomes electric by heating.

Constit. Parts.—	Silica,	42 50
	Alumina,	28.50
	Lime,	20.40
	Natron and Potash,	0.75
	Oxide of Iron,	3.00
	Water,	2.00—97.15

Laugier, Annales du Museum, t. xv. p. 205

Geognostic Situation.—This subspecies appears to be confined to secondary mountains; at least it has hitherto been found only in secondary trap rocks, as basalt, amygdaloid, basaltic-greenstone, and common greenstone. It occurs either in cotemporaneous veins, or in amygdaloidal and other shaped cavities in these trap rocks.

Geographic Situation.—In Scotland, it occurs in veins and cavities in trap-rocks near Beith in Ayrshire; Bishoptown in Renfrewshire; also at Hartfield, near Paisley; near Frisky Hall, in Cockney Burn Old Kilpatrick, and Loch Humphrey in Dunbartonshire; in Salisbury Craig, the Castle Rock, and Arthur Seat near Edinburgh; in Berwickshire; and in the islands of Mull and Raasay.

GENUS V. DATOLITE.*

Dattel Spath, *Mohs*. Esmarkite, *Hausmann*.

Three axes. Cleavage prismatic; but detected with difficulty. Internally, lustre resinous. Not blue. Hardness=5.0—5.5. Sp. gr.—2.9—3.0.

This genus contains one species, viz. Prismatic Datolite.

1. PRISMATIC DATOLITE, *Jameson*. Prismatischer Datholit, *Mohs*.

Prism = 109° 28′. Cleavage the same.

This species is divided into two subspecies, viz. Common Datolite, and Botryoidal Datolite.

FIRST SUBSPECIES.

COMMON DATOLITE, *Jameson*.—Datholit, *Werner*.

External Characters.—Colours white and grey, which latter inclines to celandine-green, and rarely to muddy honey-yellow. Occurs in massive portions, which are divided into large coarse and small granular distinct concretions; crystallized. The principal secondary forms are the following:

1. Low oblique four-sided prism. 2. Rectangular four-sided prism, flatly acuminated on the extremities, with four planes which are set on the lateral planes.

Externally shining. Internally intermediate between shining and glistening, lustre resinous. Fracture intermediate between fine-grained uneven and imperfect conchoidal. Translucent, and sometimes transparent. Very brittle. Difficultly frangible.

Chemical Characters.—When exposed to the flame of a candle, it becomes opaque, and may then be easily rubbed down between the fingers. Before the blowpipe, it intumesces into a milk-white coloured mass, and then melts into a globule of a pale rose-colour.

Constit. Parts.—	Silica,	37.0
	Lime,	28.0
	Boracic Acid,	31 0
	Alumina,	1.0
	Iron, Manganese, and Nickel,	1.5
	Water,	1 4—100

Esmark.

Geognostic and Geographic Situations.—It is associated with calcareous-spar, more rarely with fluor-spar, quartz, and sometimes prehnite, in a bed of magnetic ironstone in gneiss, at the mine of Nodebroe, near Arendal in Norway. It is said also to occur in small veins in greenstone, in the Geisalp in Sonthofen; and in the Syseralp.

SECOND SUBSPECIES.

BOTRYOIDAL DATOLITE or BOTRYOLITE, *Jameson*.—Botryolith, *Hausmann*.

This subspecies is divided into two kinds, viz. Fibrous Botryolite, and Earthy Botryolite.

First Kind.

FIBROUS BOTRYOLITE, *Jameson*.—Fasriger Botryolith, *Hausmann*.

External Characters.—Externally grey; internally white, which passes into pale rose-red. The colours are in concentric stripes. Occurs reniform, botryoidal, small globular; in fibrous concretions, which are scopiform and stellular; these concretions are again collected into granular concretions, which are traversed by very thin curved lamellar concretions. Surface granulated or rough, and dull. Internally glimmering and pearly. Fracture splintery. Translucent on the edges.

Geognostic and Geographic Situations.—It occurs in the Kjenlie mine, near Arendal in Norway, along with common quartz, schorl, calcareous spar, and iron pyrites, in a bed of magnetic ironstone, in gneiss.

Second Kind.

EARTHY BOTRYOLITE, *Jameson*.—Erdiger Botryolith, *Hausmann*.

External Characters.—Colour snow-white. Small botryoidal. Dull. Fracture earthy.

Geognostic and Geographic Situations.—It occurs along with the fibrous kind.

GENUS VI.—ZEOLITE.

Schaum Spath, *Mohs*.

Every kind of axis. Hardness ranges from 3.5, to 6.0. Sp. gravity from 2.0, to 2.5.

This genus contains the following species, viz. 1. Dodecahedral Zeolite, 2. Hexahedral Zeolite, 3. Rhomboidal Zeolite, 4. Pyramidal Zeolite, 5. Di-prismatic

* The name *Datolite* refers to the granular concretions which this species exhibits in the massive varieties, and was given to it by its discoverer, M. Esmark.

Zeolite, 6. Prismatic Zeolite, 7. Prismatoidal Zeolite, 8. Axifrangible Zeolite.† * Wavellite.

1. Dodecahedral Zeolite, or Leucite.‡ *Jameson.* Dodecaedricher Schaum Spath, *Mohs.* Leucit, *Werner.*

Tessular. Cleavage hexahedral and dodecahedral. Hardness=5.5—6.0. Specific gravity=2.4, 2.5.

External Characters.—Colours white and grey. Seldom occurs massive, and in granular concretions, most frequently in roundish imbedded grains, and crystallized in acute double eight-sided pyramids, in which the lateral planes of the one are set on the lateral planes of the other, and the summits deeply and flatly acuminated by four planes, which are set on the alternate lateral edges. Surface of the grains rough, and dull, or feebly glimmering; that of the crystals is smooth, seldom slightly streaked, in the direction of the diagonal, and glistening. Internally the lustre is shining, approaching to glistening, and is vitreous, inclining to resinous. Fracture imperfect and flat conchoidal. Translucent, semi-transparent, and some varieties approach to transparent. Refracts single. Brittle. Easily frangible.

Chemical Characters.—Before the blowpipe it is infusible without addition; with borax it forms a brownish transparent glass.

	Mean of different analyses.	
Constituent Parts.—	Silica,	54
	Alumina,	24
	Potash,	21
	Loss	1—100

Klaproth.

Geognostic and Geographic Situations.—It occurs principally in secondary trap rocks, and in lavas, and appears to be almost exclusively a production of Italy.

2. Hexahedral Zeolite, or Analcime, *Jameson.*—Hexadrischer Schaum Spath, *Mohs.* Analcime, *Hauy.* Kubizit, *Werner.*

Tessular. Cleavage hexahedral. Hardness=5.5. Sp. gravity=2.0—2.5.

External Characters.—Colour white, which passes into flesh-red. Seldom occurs massive, and this variety is disposed in coarse and small angulo-granular concretions, which are in general very closely aggregated; generally crystallized, in the following figures. 1. Perfect cube. 2. The cube flatly and deeply acuminated on all the angles with three planes, which are set on the lateral planes. 3. Acute double eight-sided pyramid, deeply and somewhat flatly acuminated on both extremities with four planes, which are set on the alternate lateral edges. Surface of the crystals smooth, and splendent or shining. Internally intermediate between shining and glistening, and the lustre vitreous, inclining to pearly. Fracture small or fine-grained uneven, or conchoidal. Fragments generally indeterminate angular, seldom more or less cubical, owing to the imperfection of the cleavage. Translucent or semi-transparent, and the crystals are transparent. Easily frangible.

Chemical Characters.—It melts with intumescence, before the blowpipe, into a transparent glass.

Physical Characters.—By friction, but not by heating, it becomes electric.

	Analcime of Montecchio-Maggiore.	
Constit. Parts.—	Silica,	58.0
	Alumina,	18.0
	Lime,	2.0
	Natron,	10.0
	Water,	8.5—96.5

Vauquelin, Annal. du Mus. d'Hist. Nat. t. ix. p. 241.

Geognostic Situation.—It occurs in primitive and secondary rocks, but more abundantly in secondary than in primitive rocks.

Geographic Situation.—It occurs in the secondary greenstone of Salisbury Craigs, in the porphyritic rock of the Calton Hill, near Edinburgh, and in many other places in Scotland.

3. Rhomboidal Zeolite, or Chabasite,§ *Jameson.*—Rhomboedrischer Schaum Spath, *Mohs.* Chabasie, *Hauy.* Schabasit, *Werner.*

Rhomboid=93° 48′. Cleavage rhomboidal. Hardness=4.0—4.5. Sp. gravity=1.0—2.1.

External Characters.—Colour greyish-white, approaching to yellowish-white. Seldom occurs massive; almost always crystallized. The following are the most frequent secondary forms: 1. Rhomboid truncated on the six obtuse lateral edges. 2. Rhomboid truncated on the six obtuse lateral edges, and on the six obtuse angles. 3. Rhomboid, in which each of the original planes of the rhomboid is divided into two. The lateral planes of the crystals are streaked in a peculiar manner; the streaks shoot from the shorter diagonal, (the dividing edge of the plane,) and run parallel with the two adjoining lateral edges of the rhomb. The truncating planes are smooth. Externally the crystals are splendent; internally glistening, and the lustre vitreous. Fracture imperfect conchoidal, and also small-grained uneven. Fragments indeterminate angular. Translucent; the crystals sometimes pass into semi-transparent.

Chemical Character.—Before the blowpipe it melts easily into a spongy white enamel.

	Chabasite of the Faroe Islands.	
Constituent Parts.—	Silica,	43.33
	Alumina,	22.66
	Lime,	3.34
	Natron, with Potash,	9.34
	Water,	21.00—99.67

Vauquelin, Annal. du Mus. d'Hist. Nat. t. ix. p. 333.

Geognostic Situation.—It occurs principally in secondary trap rocks; most frequently in cavities of amygdaloid, where it is often associated with agate, calcareous-spar, zeolite, and green-earth.

Geographic Situation.—The vesicular cavities of the trap-rocks of Mull and Skye afford crystals of chabasite; it occurs in similar rocks in the north of Ireland; and beautiful specimens are found in the amygdaloid of Iceland and of the Faroe Islands.

4. Pyramidal zeolite, or Cross-stone, *Jameson.*—Pyramidischer Schaum Spath, *Mohs.* Kreutstein, *Werner* Harmotome, *Hauy.*

Pyramid =121° 58′, 86° 36′? Cleavage is either pyra-

† Mohs names the eighth species *Axentheilender*, because its principal cleavage is perpendicular to the axis of the crystal; and this term is here translated *axifrangible*, until a more appropriate one shall occur.

‡ *Leucite*, from λευκος, *white*, and refers to its frequent white colour.

§ The name *Chabasie*, is from Chabazion, a stone described by Orpheus in his poems, but unknown to us at present.

midal, or is in the direction of the diagonals. Hardness =4 5. Sp. gravity =2 3, 2.4.

External Characters.—Colours white, grey, yellow, and red. Occurs very rarely massive; most frequently crystallized. The following are the principal secondary forms which have been observed: 1. Broad, seldom equilateral, rectangular four-sided prism, rather acutely acuminated on the extremities with four planes, which are set on the lateral edges. 2. Twin-crystal, which is formed by two crystals of No. 1. intersecting each other, in such a manner that a common axis and acumination is formed, and the broader lateral planes make four re-entering right angles. The surface of the smaller lateral planes is double plumosely streaked, the broader lateral planes transversely streaked, and the acuminating planes streaked parallel with the smaller lateral planes. Internally glistening, and the lustre intermediate between vitreous and pearly. Fracture small and perfect conchoidal, passing into uneven. Translucent, sometimes passing into semitransparent.

Chemical Characters.—Before the blowpipe it exhibits a greenish-yellow phosphorescence, and then melts with intumescence into a colourless glass.

Constituent Parts.—	Silica	49
	Alumina	16
	Barytes	18
	Water	15—98

Klap. Beit. b. ii. s. 83.

Geognostic and Geographic Situations.—It has been hitherto found only in mineral veins and in agate balls. At Andreasberg in the Hartz, it occurs in veins that traverse clay-slate and grey-wacke rocks, along with galena or lead-glance; at Kongsberg in Norway, in veins containing native silver, ores of silver, lead, zinc, arsenic, and iron; and Strontian in Argyleshire, in galena veins that traverse gneiss. At Oberstein it occurs in agate balls, in trap rocks, and in a similar situation near the village of Old Kilpatrick in Dunbartonshire.

5. Di-Prismatic Zeolite, or Laumonite, *Jameson.* Di-prismatischer Schaum Spath, *Mohs.* Lomonit, *Werner.*

Vertical prism =90° 12′; horizontal prism in the direction of the smaller diagonal 121° 34′. Cleavage double. Hardness =5. Sp. gr. =2.3—2 4.

External Characters.—Colours yellowish-white, snow-white, and greyish-white. Occurs in massive forms, arranged in large and coarse granular distinct concretions; also crystallized. Internally sometimes shining, sometimes glistening, and lustre pearly. When in a fresh state is transparent, but on exposure to the atmosphere, it very soon becomes opaque. When fresh, is rather harder than fluor-spar; but on exposure to the atmosphere, it soon becomes so soft as to yield to the mere pressure of the finger. Uncommonly easily frangible.

Chemical Character.—It forms a jelly with acids.

Constit. Parts.—	Silica,	94.0
	Alumina,	22.0
	Lime,	9.0
	Water,	17.5
	Carbonic acid,	2.5—100 *Vogel.*

Geognostic and Geographic Situations.—This mineral was first found in the year 1785, in the lead-mines of Huelgoet in Brittany, by M. Gillet Laumont, a distinguished French mineralogist. Since that period, it has been discovered in other parts of the world, as in Scotland, Ireland, Faroe Islands, &c.

6. Prismatic Zeolite or Mesotype, *Jameson.*—Prismatischer Schaum Spath, *Mohs.* Mesotype, *Hauy.*

Prism 91° 25′. Cleavage the same. Hardness =5.0—5.5. Sp. gr. =2 0—2.3.

This species is divided into three subspecies, viz. Fibrous Zeolite, Natrolite, and Mealy Zeolite.

First Subspecies.

Fibrous Zeolite, *Jameson.*—Fasriger Zeolit, *Werner.*

This subspecies is divided into two kinds, viz. Acicular or Needle Zeolite, and Common Fibrous Zeolite.

First Kind.

Acicular or Needle Zeolite, *Jameson.*—Nadelzeolith, *Werner.*

External Characters.—Colours greyish or yellowish-white, and frequently reddish-white. Occurs massive, and in distinct concretions; these are prismatic and granular; the prismatic are thin, sometimes passing into fibrous, straight, and scopiform; the granular include the prismatic, and are large and coarse. It also occurs crystallized, and the following are the secondary figures:

1. Acicular rectangular four-sided prism, very flatly acuminated, with four planes, which are set on the lateral planes. 2. The prism truncated on the edges.

Lateral planes of the crystals are longitudinally streaked, but the acuminating planes are smooth. Externally the crystals are shining, passing into splendent. Internally glistening, and lustre vitreous, inclining to pearly. Fracture small and fine-grained uneven. Translucent; crystals semitransparent and transparent; and it refracts double.

Chemical Characters.—It intumesces before the blowpipe, and forms a jelly with acids.

Physical Characters.—It becomes electric by heating, and retains this property some time after it has cooled. The free extremity of the crystal, with the acumination, shows positive, and the attached end negative electricity.—*Hauy.*

Const. Parts.—	Silica,	50 24
	Alumina	29 30
	Lime	9 46
	Water	10 00—99.00

Vauquelin, Jour. des Mines, N. 44. p. 576.

Geognostic and Geographic Situations.—It occurs in secondary trap rocks, as in basalt, greenstone, and amygdaloid. In this country it occurs near the village of Old Kilpatrick, Dunbartonshire, also in Ayrshire and Perthshire, and always in trap-rocks.

Second Kind.

Common Fibrous Zeolite, *Jameson.* Gemeiner Faser Zeolith, *Werner.*

External Characters.—Colours white, red, yellow, and yellowish-brown. Occurs massive, in blunt angular pieces, in balls, and small reniform, and these forms are composed of distinct concretions, which are fibrous and granular. The fibrous concretions are thin, straight, scopiform, and stellular; the granular, which include the fibrous, are large and coarse longish or angulo-granular, and are very much grown together. Occurs in capillary crystals. Internally it is strongly glimmering, passing into glistening, and lustre pearly. Faintly translucent. Its geognostic and geographic situations are the same with needle zeolite.

Chemical Characters.—It intumesces before the blowpipe, and forms a jelly with acids.

Constituent Parts.—Silica,	.	54.46
Alumina,	.	19.70
Lime,	.	1.61
Soda,	.	15.09
Water	.	9.83—100.63

Gehlen in Schweigger's Journ. viii. 355.

Second Subspecies.

Natrolite, *Jameson.*—Natrolith, *Werner.*

External Characters.—Colours yellow, yellowish-brown, or yellowish-white. Colours generally arranged in narrow striped delineations, which are parallel with the reniform external shape. Occurs massive, in plates, and reniform; also in distinct concretions, which are fibrous, granular, and lamellar; the fibrous are straight, and scopiform or stellular; these are collected into large and coarse granular, and both are intersected by curved lamellar concretions. Internally glistening, passing into glimmering, and lustre pearly. Fracture not visible. Translucent on the edges.

Chemical Characters.—Before the blowpipe it becomes first black, then red, intumesces, and melts into a white compact glass.

Constituent Parts.—Silica,	. .	48.00
Alumina	.	24.25
Natron,	.	16.50
Oxide of iron,		1.75
Water,	.	9.00—99.50

Klaproth. Beit. b v. s. 44.

Geognostic and Geographic Situations.—It occurs in small cotemporaneous veins in clinkstone porphyry, in the hills of Hohentwiel.

Third Subspecies.

Mealy Zeolite, *Jameson.*—Mehlzeolith, *Werner.*

External Characters.—Colours white and red. Occurs massive, reniform, coralloidal, sometimes it forms a crust over the other subspecies of zeolite, or is disposed in delicate fibrous concretions. Internally dull, or very feebly glimmering. Fracture coarse earthy. Opaque. Mass very soft, but the individual parts as hard as fibrous zeolite. Uncommonly easily frangible. Feels rough and meagre; and when we draw our finger across it, it emits a grating sound. Sometimes so light as nearly to swim in water.

Chemical Characters.—It intumesces before the blowpipe, and forms a jelly with acids.

Const. Parts.—Silica,	. . .	60.0
Alumina,	. . .	15.6
Lime,	. . .	8 0
Oxide of iron,	. .	1.8
Loss, by exposure to heat,		11.6—97

Hisinger's Afhandlingar i Fysik, &c. th. 3.

Geognostic Situation.—It occurs in similar repositories with the other subspecies.

Geographic Situation.—It is found near Tantallon Castle in East Lothian, in the islands of Skye, Mull, and Canna, also in the Faroe Islands, Iceland, and Sweden.

7. Prismatoidal Zeolite or Stilbite, *Jameson.*—Prismatoidescher Schaumspath, *Mohs.* Stilbite, *Hauy.*

Prism =90° 22′. Cleavage in the direction of the smaller diagonal very distinct. Hardness =3.5—4.0. Sp. gr. =2.0—2.2.

This species is divided into two subspecies, viz. Foliated Zeolite, and Radiated Zeolite.

First Subspecies.

Foliated zeolite, *Jameson.* Blätter-Zeolith, *Werner.*

External Characters.—Colours white, red, yellowish-grey, and pinchbeck-brown. Occurs massive, disseminated, globular, in amygdaloidal-shaped pieces; also in distinct concretions, which are large, coarse, and small angulo-granular; seldom thin and curved lamellar; which are again collected into granular. Frequently crystallized, and the following secondary forms occur: 1. Low, oblique, sometimes rather broad, four-sided prism. 2. Low six-sided prism. 3. Eight-sided prism.

Lateral planes of the prisms are transversely streaked, the terminal planes smooth. Planes sometimes shining, sometimes splendent, and the lustre vitreous. Internally alternates from shining to splendent, and the lustre pearly: the pinch-beck brown has a semi-metallic lustre. Fracture conchoidal. Massive varieties are strongly translucent: some varieties, particularly the pinchbeck-brown, are only translucent on the edges; but the crystals are generally semitransparent and transparent. Refracts single.

Chemical Characters.—It intumesces and melts before the blowpipe, and during its intumescence emits a phosphoric light. It does not form a jelly with acids.

Constit. Parts.—Silica,	. . .	52 6
Alumina,	. .	17.5
Lime	. . .	9.0
Water	. . .	18 5—97.6

Vauquelin, Jour. des Mines, N. xxxix. p. 164.

Geognostic Situation.—It occurs principally in secondary amygdaloid, either in drusy cavities, along with calcareous-spar and calcedony, or in cotemporaneous veins. It is also met with in primitive and transition mountains.

Geographic Situation.—In Scotland it occurs in drusy cavities or veins in the secondary trap-rocks that abound in the middle division of the country. Very beautiful specimens of the red foliated and radiated zeolites are found at Carbeth in Stirlingshire, and at Loch Humphrey in Dunbartonshire; and the same varieties occur on the coast between Bervie and Stonehaven in Angus-shire; also in the secondary trap-rocks of the Hebrides, as of Canna, Skye, and Mull. In the north of Ireland it is an inmate of secondary trap-rocks.

Second Subspecies.

Radiated zeolite, *Jameson.* Strahl Zeolith, *Werner.*

External Characters.—Occurs almost always white; sometimes grey, yellow, flesh-red, and blood-red. Is found massive, in angular pieces, and globular; also in distinct concretions, which are prismatic and granular; the prismatic are broad and narrow scopiform, and stellular, and are collected into large, coarse, and small angulo-granular concretions. Frequently crystallized. Primitive figure the same as that of foliated zeolite; and it exhibits the following secondary forms:

1. Broad rectangular four-sided prism, rather acutely acuminated on both extremities by four planes, which are set on the lateral edges. 2. Sometimes No. 1. is so thin, that it may be considered as a long six-sided table, bevelled on the shorter terminal planes.

The broader lateral planes of the crystals are smooth, the smaller longitudinally streaked, and the acuminating planes smooth or rough. The surfaces of the broader lateral planes of the crystals, No. 1, 2. are splendent and pearly: the other planes shining and vitreous: internally the lustre more or less shining and pearly. Crystals strongly translucent, sometimes passing into semi-transparent. Hardness same as foliated zeolite. Brittle. Easily frangible.

Its Geognostic and Geographic Situations are the same as those of Foliated Zeolite.

8. Axifrangible Zeolite or Apophyllite, *Jameson*.—Fishaugenstein, *Werner*. Apophyllite, *Hauy*. Ichthyophthalm, *Karsten*.

Pyramid unknown. Cleavage very distinctly axifrangible. Hardness =4.5—5.0. Sp. gr. =2.2—2.5.

External Characters.—Principal colour white. Surface of the cleavage strongly iridescent. Occurs massive, and disseminated; massive varieties are composed of straight and curved lamellar distinct concretions, with feebly streaked splendent pearly surfaces. The following are the secondary forms:

1. Rectangular four-sided prism, sometimes so low as to appear tabular, and resemble a cube. The preceding figure truncated on all the angles: when the truncating planes become so large that they touch each other, the prism appears acuminated with four planes, which are set on the lateral edges, and the apex of the acumination truncated. 3. The rectangular four-sided prism, in which all the lateral edges are truncated, thus forming an eight-sided prism; sometimes the eight solid angles of this figure are truncated. 4. The rectangular four-sided prism bevelled on all the edges, or only on some of them: sometimes one of the bevelling planes is awanting, when the edge appears to be only obliquely truncated. 5. Slightly oblique four-sided prism. Formed when the truncating planes of No. 3. become so large that the original planes disappear. 6. Rectangular four-sided prism, in which the angles are truncated, and the edges bevelled. 7. Rectangular four-sided table, in which the two opposite broader terminal planes are doubly bevelled, and the two smaller planes very flatly acuminated with four planes, of which two are set on the lateral planes, the other two on the terminal planes, and the terminal edges bevelled.

Crystals very small, small, middle-sized, and very rarely large. The surface of the crystals Nos. 1, 2. and 4. is smooth; the surface of Nos. 3. and 5. and the acuminating planes of No. 7. are longitudinally furrowed; the bevelling planes of Nos. 4. 6. and 7. are transversely streaked. All the other planes of the secondary crystals are smooth. The middle point of the end of the crystals is often concave. Lateral planes occasionally bulging, and the terminal planes rose-like. Externally splendent; but only the terminal planes of the prism pearly. Fracture small and perfect conchoidal, and the lustre glistening and vitreous. Semitransparent, passing into transparent, and into translucent. Refracts single.

Chemical Characters.—It exfoliates very readily before the blowpipe, (it even exfoliates when held in the flame of a candle,) and melts easily into a white-coloured enamel.

Physical Characters.—It becomes feebly electric by rubbing.

		Apophyllite of Utön.
Const. Parts.—	Silica,	52.00
	Lime,	24.50
	Potash,	8 10
	Water,	15.00—99.60. *Rose*.

Geognostic and Geographic Situations.—It occurs in the secondary trap-rocks of the island of Skye; in rocks of the same description in the Faroe islands; in the island of Disco in West Greenland, and on the mainland of Greenland. One of the earliest known localities of this mineral is the island of Uton, not far from Stockholm, where it occurs in beds of magnetic-ironstone, along with common felspar, calcareous-spar, and hornblende.

*Wavellite, *Jameson*.

External Characters.—Colours greyish-white, greenish-white, ash-grey, asparagus-green, and sometimes spotted-brown. Occurs botryoidal, globular, stalactitic; and these forms are composed of fibrous or fine prismatic distinct concretions, which are scopiform or stellular; sometimes these prismatic concretions are collected into granular, and both are occasionally traversed by lamellar concretions. Occurs crystallized in the following figures:

1. Very oblique four-sided prism, flatly bevelled on the extremities, the bevelling planes set on the obtuse lateral edges. 2. The preceding figure very deeply truncated on the obtuse lateral edges. Cleavage prismatic. Externally shining; internally shining, passing into splendent; and lustre pearly. Translucent. Hardness =3.5—4.0. Sp. gr. 2.270, *Lucas*.—2.22, 2.253, *Gregor*.—2.25. 2.4, *Aitken*.

Chemical Characters.—It becomes opaque and soft by the action of the blowpipe, but neither decrepitates nor fuses. By the aid of heat it is soluble in the mineral acids and fixed alkalies, with effervescence, and leaves very little residue.

Constituent Parts.

Barnstaple Wavellite.		
Alumina,	71.59	70.0
Oxide of iron,	0.50	—
Lime,		1.4
Water,	28.0	26.2
	100	97.6
	Klap. Beit. b. iv. s. 110.	*Davy*, Nichol. Journ. xii. 157.

Alumina,	35.55
Phosphoric acid,	33.40
Fluoric acid,	2.06
Lime,	0.50
Iron and Manganese,	1.25
Water,	26.80
	99.36
	Berzelius.

From this analysis of Berzelius, wavellite appears to be hydrous phosphat of alumina.

Geognostic and Geographic Situations.—This mineral occurs in veins, along with fluor-spar, quartz, tinstone, and copper-pyrites, in granite, at St. Austle in Cornwall. At Barnstaple in Devonshire, where it was first found by Dr. Wavell, it traverses slate-clay in the form of small cotemporaneous veins. The Secretary of the Wernerian Society, Mr. Neill, found it in a similar situation in Corrivelan, one of the Shiant Isles, in the Hebrides.

Genus VII. FELSPAR.

Rhomboidal, pyramidal, prismatic. Imperfectly axifrangible. Hardness =5.0—6.0. Sp. gr. =2.5—2.8.

I. Rhomboidal Felspar, or Nepheline, *Jameson*. Rhomboedrischer Feldspath, *Mohs*. Nepheline, *Hauy* and *Werner*.

Di-rhomboid =152° 44′; 56° 15′. Cleavage is fourfold. Three of the cleavages are parallel with the lateral planes, and one with the terminal planes, of the six-sided prism. Hardness =6.0. Sp. gr. =2.5—2.6.

External Characters.—Colours white and grey. Occurs massive and crystallized. The secondary forms are the following:

1. Perfect equiangular six-sided prism. 2. The preceding figure, truncated on the terminal edges. 3. Thick six-sided table, in which the lateral edges are truncated.

Externally crystals splendent: internally shining, and lustre vitreous. Fracture conchoidal. Strongly translucent, passing into transparent.

Chemical Characters.—It melts with difficulty before the blowpipe into a dark glass.

Constit. Parts.—Silica,	46	
Alumina,	49	
Lime,	2	
Oxide of Iron,	1—98,	*Vauquelin.*

Geognostic and Geographic Situations.—It occurs in drusy cavities in granular limestone, along with ceylanite, vesuvian, and meionite, at Monte Somma, near Naples; also in fissures of basalt at Capo di Bove, near Rome. It is mentioned also as a production of the Isle of Bourbon.

II. Prismato-Pyramidal Felspar or Meionite, *Jameson.* Prismato-Pyramidischer Feldspath, *Mohs.* Meionite, *Hauy* and *Werner.*

Pyramid =136° 22′, 63° 22′. Cleavage in the direction of the diagonals of the prism. Hardness =5.5. Sp. gr. =2.5—2.7.

External Characters.—Colour greyish-white. Occurs sometimes massive, but more frequently crystallized. The following are the secondary figures:

1. Rectangular four-sided prism, flatly acuminated with four planes, which are set on the lateral edges. 2. The preceding figure, truncated on the lateral edges. 3. No. 1. bevelled on the lateral edges, and the edges of the bevelment truncated; and the edges between the acuminating planes and the lateral planes also truncated.

Externally crystals smooth and splendent, internally splendent and vitreous. Generally transparent or semi-transparent, seldom translucent.

Chemical Characters.—It is easily fusible before the blowpipe; intumesces during fusion, and is converted into a white vesicular glass. It has not hitherto been analysed.

Geognostic and Geographic Situations.—It occurs, along with ceylanite and nepheline, in granular limestone, at Monte Somma, near Naples. It is said also to occur in basalt, along with augite and leucite, at Capo di Bove, near Rome.

III. Prismatic or Common Felspar, *Jameson.*—Prismatischer Feldspath, *Mohs.*

Prism =120°. The most distinct cleavage is that parallel with the terminal planes of the prism; other two, less distinct, parallel with the lateral planes. Hardness =6.0. Sp. gr. =2.5—2.8.

This species is divided into nine Subspecies, viz. 1. Adularia, 2. Glassy-Felspar, 3. Ice-Spar, 4. Common Felspar, 5. Labrador Felspar, 6. Compact Felspar, 7. Clinkstone, 8. Earthy Common Felspar, and, 9. Porcelain Earth.

First Subspecies.

Adularia, *Jameson.* Adular, *Werner.*

External Characters.—Principal colour greenish-white, which sometimes passes into greyish-white and milk-white, and even inclines to asparagus-green. It is frequently iridescent; and the milk-white varieties, in thin plates, when held between the eye and the light, sometimes appear pale flesh-red. Occurs massive, and this variety is composed of granular and thick lamellar concretions; and frequently crystallized. The following are the most frequent secondary figures:

1. Oblique four-sided prism, flatly bevelled on the extremities, and the bevelling planes set on the obtuse lateral edges. 2. Broad six-sided prism, flatly bevelled on both extremities, and the bevelling planes set on the lateral edges, which are formed by the smaller lateral planes. 3. Rectangular four-sided prism, in which the terminal planes are obliquely bevelled.

Lateral planes of the prism longitudinally streaked. Externally splendent; internally cleavage splendent, and the fracture shining and glistening. Lustre intermediate between vitreous and pearly. Semi-transparent, sometimes inclining to transparent, or is translucent. Translucent varieties, when viewed in a certain direction, sometimes exhibit a silvery or pearly light. Refracts double.

Chemical Characters.—It melts before the blowpipe, without addition, into a white-coloured transparent glass.

Constituent Parts.—Silica,	64	
Alumina,	20	
Lime,	2	
Potash,	14—100.	*Vauquelin.*

Geognostic Situation.—It occurs in cotemporaneous veins in drusy cavities in granite and gneiss.

Geographic Situation.—It occurs in the granite of the island of Arran; and in the granite and gneiss rocks of Norway, Switzerland, France, and Germany.

Uses.—The variety of adularia which exhibits the bluish pearly light is valued by jewellers, and is sold by them under the name *Moonstone.* Another variety of adularia, found in Siberia, is known to jewellers under the name *Sunstone.* It is of a yellowish-grey colour, and numberless golden spots appear distributed throughout its whole substance.

Second Subspecies.

Glassy Felspar, *Jameson.* Glasiger Feldspath, *Werner.*

External Characters.—Colour greyish-white, sometimes passing into grey. Occurs always crystallized, in broad rectangular four-sided prisms, bevelled on the extremities. These crystals are often very much cracked; they are generally small, seldom middle-sized, and always imbedded. Internally splendent, and lustre vitreous. Fracture uneven, or small and imperfect conchoidal. Transparent.

Constituent Parts.—Silica,	68.0
Alumina,	15.0
Potash,	14.5
Oxide of iron,	0.5—98.0

Klaproth, Beit. b. v. s. 18.

Geognostic and Geographic Situations.—It occurs imbedded in pitchstone-porphyry in Arran and Rum; in a porphyritic rock in the Siebengebirge; also in a rock composed of white felspar, and very small blackish-brown scales of mica, and fine disseminated magnetic ironstone, in the Drachenfels on the Rhine.

Third Subspecies.

Ice-Spar, *Jameson.*—Eispath, *Werner.*

External Characters.—Colour white. Occurs massive, cellular, and porous; also in large granular concretions, which are composed of thin and straight lamellar concretions. Frequently crystallized in the form of small thin longish six-sided tables, in which the shorter terminal planes are bevelled. Externally crystals shining, and sometimes splendent; internally shining, and lustre vitreous. Massive and other varieties strongly translucent; crystals transparent.

Geognostic and Geographic Situations.—It occurs, along with nepheline, meionite, mica, and hornblende, at Monte Somma, near Naples.

Fourth Subspecies.

Common Felspar, *Jameson*.—Frischer Gemeiner Feldspath, *Werner*.

External Characters.—Most frequent colours white and red, seldom grey, and rarely green and blue. Occurs most frequently massive and disseminated, seldom in blunt angular rolled pieces and grains, and frequently in granular distinct concretions, from the smallest to the largest size; and sometimes crystallized, in the same form nearly as adularia. Internally cleavage shining, and sometimes splendent. Fracture glistening, and frequently not more than feebly glistening. Lustre intermediate between vitreous and pearly, but inclining rather more to the former than to the latter. Fracture uneven or splintery. Fragments rhomboidal, and have only four splendent shining faces. Translucent, or only translucent on the edges.

Chemical Characters.—Before the blow-pipe, it is fusible without addition into a grey semi-transparent glass.

Constituent Parts.

Siberian Green Felspar.		Flesh-red Felspar.	Felspar from Passau.
Silica,	62.83	66.75	60 25
Alumina,	17.02	17 50	22.00
Lime,	3 00	1.25	0.75
Potash,	13.00	12.00	14 00
Oxide of Iron,	1.00	0.75	a trace.
Water,			1 00
	96 85	98.25	98 00
	Vauquelin, Jour. des Mines, n. 49, p. 23.	*Rose*, in Scherer's Jour. der Chimie, b. 7. s. 244.	*Bucholz*, in Von Moll's Neue Jahrb der Berg und Huttenkunde, b 2, s. 361.

Geognostic Situation.—Felspar occurs in most of the primitive rocks; in many of the species of the transition class, and also associated with secondary and volcanic rocks.

Uses.—It is one of the ingredients in the finer kinds of earthen-ware, and is said to be the substance used by the Chinese under the name *Petunse* or *Petunze*, in the manufacture of their porcelain. The green varieties of felspar, which are rare, are considered as ornamental stones, and are cut and polished, and made into snuff-boxes, and other similar articles. When the green varieties are spotted with white, they are named *Aventurine Felspar*, and are prized by collectors.

Fifth Subspecies.

Labrador Felspar, *Jameson*.—Labradorstein, *Werner*.

External Characters.—Most frequent colours light and dark ash-grey, and smoke-grey, seldom yellowish-grey. When light falls on it in determinate directions, it exhibits a great variety of colours; of these the most frequent are blue and green, more seldom yellow and red, and the rarest variety is pearl-grey. Occurs massive, or in rolled pieces, also in large, coarse, seldom in small granular, very seldom in thick and straight lamellar concretions. Cleavage splendent, fracture glistening, and the lustre intermediate between vitreous and pearly. Translucent, but in a low degree.

Chemical Characters.—According to Mr. Kirwan, it is more infusible than common felspar.

Geognostic and Geographic Situations.—It occurs in rolled masses of syenite, in which it is associated with common hornblende, hyperstene, and magnetic ironstone, in the island of St. Paul, on the coast of Labrador, where it was first discovered, upwards of thirty years ago, by the Moravian Missionaries settled in that remote and dreary region. Since that time it has been found in Scotland, Norway, and other countries.

Uses.—On account of its beautiful colours, it is valued as an ornamental stone, and is cut into ring-stones, snuff-boxes, and other similar articles. It receives a good polish; but the streaks caused by the edges of the folia of the cleavage are frequently so prominent as to injure the appearance of the stone.

Sixth Subspecies.

Compact Felspar, *Jameson*. Dichter Feldspath, *Werner*.

External Characters.—Colours white, grey, green, and red. Occurs massive, disseminated, in blunt angular rolled pieces, and in small angulo-granular concretions; also crystallized in rectangular four-sided prisms. Crystals either middle sized, or small, and always imbedded. Internally sometimes glistening, sometimes glimmering. Fracture even and splintery. Feebly translucent, sometimes only translucent on the edges.

Chemical Characters.—Before the blowpipe it melts with difficulty into a whitish enamel.

Constituent Parts.

Compact Felspar of Salberg, in Sweden.

Silica	68.0	Silica	51.00
Alumina	19.0	Alumina	30 50
Lime	1.0	Lime	11.25
Potash	5.5	Iron	1.75
Oxide of Iron	4.0	Natron	4.00
Water	2.5—100	Water	1 26—99.75
Godon de St. Memin, Journal de Physique. t. 63. p. 60.		*Klaproth*. Chem. Abhandl. s. 264.	

Geognostic Situation.—This mineral occurs in mountain-masses, beds and veins, either pure, or intermixed with other minerals, in primitive, transition, and secondary rocks.

Geographic Situation.—The Pentland Hills contain beds of compact felspar, associated with claystone, red sandstone, and conglomerate. It occurs in a similar situation on the hill of Tinto, and in the Ochil Hills; and associated with rocks of the same nature in the Island of Papa Stour, one of the Shetland group.

Seventh Subspecies.

Clinkstone, *Jameson*. Klingstein, *Werner*. Phonolith, *Daubuisson*.

External Characters.—Colours grey, green, and brown. Occurs massive; also in granular, columnar, globular, and tabular distinct concretions. Lustre of the principal fracture glistening and pearly; that of the cross fracture faintly glimmering, almost dull. Principal fracture slaty, generally thick, and often curved slaty, with a scaly foliated aspect; the cross fracture splintery, passing into even, and flat conchoidal. Strongly translucent on the edges, sometimes even translucent. In thin plates, it emits, when struck, a ringing sound.

Chemical Characters.—It melts before the blowpipe into a grey coloured glass, but is more difficultly fusible than basalt.

Const. Parts.	Silica	57.25
	Alumina	23.50
	Lime	2.75
	Natron	8.10
	Oxide of Iron	3.25
	Oxide of manganese	0.25
	Water	3.00—98.10

Klaproth, Beit. b. iii. s. 243.

Geognostic Situation.—This subspecies of felspar generally contains imbedded crystals, when it forms the rock named Clinkstone Porphyry. It is generally associated with secondary trap and porphyry rocks.

Geographic Situation.—The Bass rock at the mouth of the Frith of Forth, North Berwick Law, Traprain Law, and the Girleton Hills, all in East Lothian, and many other hills in Scotland, contain beds and veins of this mineral.

Eighth Subspecies.

Earthy Common Felspar, *Jameson.* Aufgelöster gemeiner Feldspath, *Werner.*

External Characters.—Colours white and grey. Generally occurs massive, and disseminated, and sometimes in imbedded crystals, which agree in form with those of common felspar. Internally sometimes glistening, sometimes glimmering, or even dull. Has sometimes an imperfect cleavage. Fracture coarse and small grained uneven, which approaches to earthy. Breaks into blunt angular pieces. Either translucent on the edges, or opaque. In general, it is so soft as to yield to the nail; sometimes, however, it approaches in hardness to felspar. Sectile, and easily frangible.

The chemical characters and composition of this substance have not been ascertained

Geognostic and Geographic Situations.—It occurs in granite and gneiss districts, as in Cairngorm and Arran in Scotland, and Cornwall in England. It is well known in Saxony, and other countries.

Ninth Subspecies.

Porcelain Earth, or Kaolin, *Jameson.* Porcellanerde, *Werner.*

External Characters.—Most frequent colour reddish white, of various degrees of intensity; also snow-white and yellowish-white. Generally friable, and sometimes approaches to compact. Composed of dull dusty particles, which are feebly cohering. Soils strongly. Feels fine and soft, but meagre. Adheres slightly to the tongue. Specific gravity, 2.216, Karsten.

Chemical Characters.—It is infusible before the blowpipe.

Constituent Parts.

		Porcelain Earth from Aue in Saxony.			
Silica	46 0	Silica	52.00	Silica	55.0
Alumina	39.0	Alumina	47 00	Alumina	42.5
Oxide of Iron	0.25	Iron	0.33	Iron	1.0
Water	14 50			Lime	1.0
	97 75		99.33		99.5
Klaproth, Chem. Abhandl. s. 278.			*Rose.*		*Gehlen.*

Geognostic Situation.—It generally occurs in granite and gneiss countries, either in beds contained in the granite or gneiss, when it appears to be an original deposite, or on the sides and bottom of granite and gneiss hills, when it is certainly formed by the decomposition of the felspar of these rocks.

Geographic Situation.—It occurs in different granite and gneiss districts in Scotland, and in the Shetland Isles; also in England and Ireland, and in many places on the continent of Europe.

Uses.—This mineral forms a principal ingredient in the different kinds of porcelain. It is not used in the state in which it is found in the earth, but is previously repeatedly washed, in order to free it from impurities. After the process of washing, only fifteen parts of pure white clay remain, which is the kaolin of the Chinese. Porcelain has been manufactured in China and Japan from a very early period. The art itself was discovered in Europe, by a German named Bötticher, who made his first porcelain-vessels in Dresden, in the year 1706. These were of a brown and red colour. The white was not attempted until the year 1709; and the famous manufactory at Meissen, the earliest in Europe, was established in 1710.

4. Pyramidal Felspar, or Scapolite † *Jameson.*—Pyramidaler Feldspath, *Mohs.* Scapolit, *Werner.* Paranthine, *Hauy.*

Pyramid = 136° 28′—62° 56′. Cleavage is in the direction of the lateral planes, and of the diagonals of a rectangular four-sided prism. Hardness = 5 0—5.5. Sp. gr. = 2.5—2.8.

This species is divided into four subspecies, viz. Radiated Scapolite, Foliated Scapolite, Compact Red Scapolite, and Elaolite.

First Subspecies.

Radiated Scapolite, *Jameson.*

External Characters.—Most frequent colour grey, seldomer white and green. Occurs massive, and in distinct concretions; concretions radiated or fibrous, scopiform diverging, and are collected into others which are thick and wedge-shaped. It is most frequently crystallized. The secondary forms are the following:

1. Rectangular four sided prism, flatly acuminated on the extremities with four planes, which are set on the lateral planes. 2. The preceding figure, in which the lateral edges are truncated.

Lateral planes of the crystals deeply longitudinally streaked, and shining. Internally intermediate between shining and glistening, and the lustre intermediate between resinous and pearly. Fracture fine-grained uneven. Translucent, and semitransparent in crystals.

Chemical Characters.—Green scapolite, before the blowpipe, becomes white, and melts into a white glass.

Constituent Parts.—Silica,	. .	45.0
Alumina,	. .	33.0
Lime,	. .	17.6
Natron,	. .	1.5
Potash,	. .	0.5
Iron and Manganese,		1.0—98.6

Laugier, Annales du Museum d'Hist. Nat. cah. lx. p. 472.

Geognostic and Geographic Situations.—This mineral occurs in the neighbourhood of Arendal in Norway, where it is associated with magnetic ironstone, felspar, quartz, mica, garnet, augite, hornblende, actynolite, and calcareous-spar.

Second Subspecies.

Foliated Scapolite, *Jameson.*

External Characters.—Principal colours grey, green, and black. Occurs massive, disseminated, and in large, coarse, and long angulo-granular concretions; also crystallized in low eight-sided prisms, flatly acuminated with four planes, which are set on the alternate lateral planes. Externally crystals shining or splendent, and vitreous. Cleavage shining, fracture glistening; lustre intermediate between resinous and pearly. Generally translucent, and passes sometimes into transparent, sometimes to translucent on the edges. Yields a white streak.

Geognostic and Geographic Situations.—It occurs in Sweden, in primitive rocks.

Third Subspecies.

Compact Red Scapolite, *Jameson.* Dichter Scapolite.

External Characters.—Colour dark brick-red, passing into pale blood-red. Seldom occurs massive, more frequently crystallized, in long, frequently acicular, four-sided prisms, which are often curved, and are without terminal crystallizations. Externally crystals rough and dull. Internally very feebly glistening, almost glimmering. Fracture fine-grained uneven, approaching to splintery. Opaque, or very faintly translucent on the edges.

Geognostic and Geographic Situations.—It occurs along with the other subspecies, in metalliferous beds, at Arendal in Norway.

Fourth Subspecies.

Elaolite, *Jameson.*—Eläolith, *Klaproth.* Fettstein, *Werner.* Dichter Wernerit, *Hausmann.*

External Characters.—Colours of this mineral blue, which inclines more or less to green, also flesh-red, which falls more or less into grey, sometimes even inclines to brown. Occurs massive, and in very intimately aggregated granular concretions. Internally shining or glistening, lustre resinous. Fracture principally in the red variety, flat and imperfect conchoidal. Blue variety has an imperfect double cleavage. Translucent in a low degree. Blue variety, when cut in a particular direction, displays a peculiar opalescence, not unlike that observed in the cat's-eye. Has the same degree of hardness as the other subspecies.

Chemical Character.—When pounded, and thrown into acids, it gelatinates. Before the blowpipe it melts into a milk-white enamel.

Constituent Parts.—Silica,	.	44.00
Alumina,	.	34.00
Lime,	.	0.12
Potash and Soda,		16.50
Oxide of Iron,		4.00—98.62

Vauquelin, in Hauy's Tabl. Comparative, p. 178.

Geognostic and Geographic Situations.—The blue variety is found at Laurwig, and the red at Stavern and Friedrichwärn, both in the rock named *zircon syenite.*

Uses.—The pale-blue variety, which has often an opalescence like that of the adularia-moonstone, is cut *en cabochon*, and used for ring-stones. When set, it is difficult to distinguish it from cat's-eye.

Observations.—Few of the newer mineral species have had so many names given to them as Scapolite, as appears from the following enumeration: 1. Paranthine; 2. Wernerite; 3. Arcticite; 4. Sodaite; 5. Natrolite; 6. Fuscite; 7. Gabbronite; 8. Elaolite; 9. Fettstein; 10. Lythrodes; 11. Spreustein; 12. Bergmannite.

* Chiastolite, *Jameson.*—Hohlspath, *Werner.*

External Characters.—Colours white and grey; the white colours yellowish-white, greenish-white, greyish-white, and reddish-white; grey colours pearl-grey, greenish-grey, and yellowish-grey. Occurs always crystallized. Primitive form appears to be an oblique four-sided prism, with lateral edges of 84° 48′, and 95° 12′. The following are the secondary forms:

1. Four-sided prism, in which the lateral edges are rounded. 2. Four prisms arranged in the form of a cross.

These crystals always appear as if they had been at one time hollow, and these hollows filled up with clay-slate, the position of which varies in regard to the crystals. Cleavage double, and in the direction of the lateral planes of the prism. Lustre of the cleavage glistening, that of the fracture glimmering. Fracture splintery. Translucent. Hard. Scratches glass. Rather difficultly frangible. Sp. gr. 2.944, Hauy. 2.944, Karsten.

Chemical Characters.—It is infusible before the blowpipe, and becomes white and nearly opaque.

Its constituent parts have not as yet been ascertained.

Geognostic and Geographic Situations.—It occurs in small acicular crystals in clay-slate in Wolfscrag near Keswick, and near the summit of Skiddaw in Cumberland; also at Aghavanagh, and Baltinglas-hill, in the county of Wicklow. The largest and most beautiful crystals are found in clay-slate near to St. Brieux in Brittany; smaller crystals occur in the clay-slate of St. Jago di Compostella in Gallicia.

Observations.—Chiastolite is placed immediately after the species of the felspar genus, on account of its supposed affinity with them; but its characters are still so imperfectly known, that it cannot be arranged in any of the present genera.

** Sodalite, *Jameson.*—Sodalite, *Thomson.*

External Characters.—Colour intermediate between celandine and mountain-green. Occurs massive, and crystallized in rhomboidal or garnet dodecahedrons. Externally smooth, shining or glistening; internally longitudinal fracture vitreous, cross fracture resinous. Has a double cleavage. Fracture conchoidal. Fragments indeterminate angular, and sharp-edged. Translucent. Hard as felspar. Brittle. Easily frangible. Specific gravity=2.378.

Chemical Characters.—When heated to redness, it does not decrepitate, nor fall to powder, but becomes dark-grey; and is infusible before the blowpipe.

Const. Parts.—Silica,	.	38.52
Alumina,	.	27.58
Lime,	.	2.70
Oxide of Iron,	.	1.00
Soda,	.	25.50
Muriatic Acid,	.	3.00
Volatile Matter,	.	2.10
Loss,	.	1.70—100.00

Thomson, in Tr. R. S. of Ed. vol. vi. p. 394.

Geognostic and Geographic Situations.—It was discovered at Kanerdluarsuk, a narrow tongue of land, upwards of three miles in length, in lat. 61°, in West Greenland, by Sir Charles Giesecké. It is found in a bed from six to twelve feet thick, in mica-slate, and is associated with sahlite, augite, hornblende, and garnet.

Clay and Lithomarge Families.—The minerals included under these titles have no regular form or cleavage, and cannot therefore be connected with any of the mineral species. We place them here on account of their affinity with some of the members of the preceding genus.

* Clay Family.

In this group or family we include the following minerals, 1. Aluminite, 2. Common Clay, 3. Variegated Clay, 4. Slate-Clay, 5. Bituminous Shale, 6. Claystone, 7. Adhesive Slate, 8. Polier Slate, 9. Tripoli.

** Lithomarge Family.

The minerals of this family have many alliances with the preceding, and hence are placed immediately after them.

1. Lithomarge, 2. Mountain Soap, 3. Yellow Earth, 4. Bole.

* Clay Family.

1. Aluminite, *Jameson.*—Reine Thonerde, *Werner.*

External Characters.—Colour snow-white, which verges on yellowish-white. Occurs in small reniform pieces. Dull. Fracture fine earthy; consistence intermediate between friable and solid. Opaque. Soils slightly. Affords a glistening streak. Adheres feebly to the tongue. Passes from very soft into friable. Feels fine, but meagre.

Constituent Parts.—Alumina,	.	31.0
Water,	.	45.0
Sulphuric Acid,		21.5
Lime,	.	2.0—99.5

Bucholz.

Geognostic and Geographic Situation.—It occurs in calcareous loam in the alluvial strata around Halle in Saxony.

2. Common Clay, *Jameson.*

Under this head we include Loam and Potter's-Clay.

Loam, *Jameson.*—Leim, *Werner.*

External Characters.—Colour yellowish-grey, sometimes inclining to greenish-grey, and is spotted yellow and brown. Occurs massive. Dull, and feebly glimmering, when small scales of mica are present. Fracture coarse and small-grained uneven in the large, and in the small earthy. Soils slightly. Very easily frangible. Sectile, and the streak slightly resinous. Intermediate between friable and soft, but inclining more to the first. Adheres slightly to the tongue. Feels rather rough, and very slightly greasy, or meagre.

Geognostic and Geographic Situations.—It occurs in great beds in alluvial districts.

Uses.—The mud-houses we meet with in different countries are built of loam. The use of loam-bricks is of high antiquity; for we are told that the ancient city of Damascus, and the walls of Babylon, were built of bricks of this substance.

Potter's-Clay.—Töpferthon, *Werner.*

a. Earthy Potter's-Clay, *Jameson.*—Erdiger Töpferthon, *Werner.*

There are two kinds of this clay, viz. Earthy and Slaty.

External Characters.—Colours white and grey; very seldom mountain-green. Occurs massive; friable, approaching to solid. Internally dull, or feebly glimmering, from intermixed scales of mica. Fracture in the large coarse-grained uneven; in the small fine earthy. More or less shining in the streak. Fragments very blunt-edged. Opaque. Soils slightly. Very soft, passing into friable. Sectile. Adheres strongly to the tongue; more strongly than loam. Feels rather greasy. Becomes plastic in water.

Chemical Characters.—It is infusible.

Constituent Parts.—Silica,	.	61
Alumina,	.	27
Oxide of Iron,	.	1
Water,	.	11—100

Klaproth, Chem. Abhandl. s. 282.

Geognostic Situation.—It is a frequent mineral in alluvial districts, where it sometimes occurs in beds of considerable thickness; it has also been observed in secondary or flœtz formations.

Geographic Situation.—It occurs in many districts in England, Scotland, and Ireland.

Uses.—It is used in potteries, in the manufacture of the different kinds of earthen-ware; it is also made into bricks, tiles, crucibles, and tobacco-pipes; and is employed in improving sandy and calcareous soils.

(*b.*) Slaty Potter's-Clay, *Jameson.*—Schiefriger Töpferthon, *Werner.*

External Characters.—Most frequent colour dark smoke-grey, seldomer bluish and pearl-grey. Occurs massive. Lustre of the principal fracture glistening; cross-fracture dull. Principal fracture very imperfect slaty; cross-fracture fine earthy. Fragments often tabular. Does not adhere so strongly to the tongue as the earthy kind, but becomes more shining in the streak; feels more greasy.

Geognostic Situation.—It occurs in considerable beds in alluvial districts, along with earthy Potter's-clay.

3. Variegated Clay, *Jameson.*—Bunter Thon, *Werner.*

External Characters.—Colours white, grey, yellow, red, and brown. Occurs massive. Internally dull. Fracture coarse earthy, inclining to slaty. Fragments blunt-edged. Becomes strongly resinous in the streak, more so than the preceding kinds. Soft, inclining to friable. Sectile. Adheres pretty strongly to the tongue. Feels rather greasy.

Geognostic and Geographic Situations.—It occurs in alluvial deposites near Weirau, in Upper Lusatia.

4. Slate-Clay, *Jameson.*—Schiefer Thon, *Werner.*

External Characters.—Colours smoke and ash grey, greyish-black, and sometimes bluish and yellowish-grey, and brownish-red. Occasionally contains impressions of unknown ferns and reeds. Massive, dull, or glimmering, owing to the intermixed scales of mica. Fracture in the large more or less perfect slaty; in the small, earthy. Fragments tabular. Opaque. Intermediate between soft and very soft. Affords a dull grey-coloured streak. Easily frangible. Adheres slightly to the tongue. Feels somewhat greasy. Specific gravity, 2.636, *Karsten* —2.680 *Kirwan.*

Geognostic Situation.—It occurs in beds in all the secondary coal-formations. It passes into claystone, sandstone, and bituminous-shale, and sometimes inclines to clay-slate.

Geographic Situation.—It occurs more or less abundantly in all the coal-districts in this island.

5. Bituminous Shale, *Jameson.*—Brandschiefer, *Werner.*

External Characters.—Colour light brownish-black, which sometimes passes into blackish-brown. Occurs only massive. Internal lustre feebly glimmering. Fracture rather thin and straight slaty. Fragments tabular. Opaque. Becomes resinous in the streak, but the colour not changed. Very soft, approaching to soft. Rather sectile, and easily frangible. Feels rather greasy. Specific gravity, 1.991, 2.049, *Kirwan*, 2.060, *Karsten.*

Geognostic Situation.—It occurs principally in rocks of the coal-formation, where it frequently alternates with, and passes into, slate-clay, and also into coal.

Geographic Situation.—It occurs in all the coal districts in this island, and also in those of Bohemia, Poland, Silesia, and other countries.

6. Claystone. *Jameson.*—Thonstein, *Werner.*

External Characters.—Colours grey, white, blue, and red. Sometimes veined, spotted, and striped. Occurs massive. Internally dull, when it does not contain accidentally mixed glimmering particles. Fracture fine earthy, but sometimes passes to fine-grained uneven, and even inclines to slaty and conchoidal. Opaque. Semi-hard, sometimes soft, and even very soft. Specific gravity, 2.210 *Karsten.*

Geognostic Situation.—It occurs in beds, along with porphyry; also forming the basis of clay porphyry, in beds, along with black coal, and as a constituent of some kinds of tuff.

Geographic Situation.—It occurs along with secondary porphyry in the Pentland Hills; in a similar situation in the island of Arran; on the mountains of Tinto; in the Ochil Hills; and in many other places of Scotland.

Uses.—When of sufficient hardness, it is used as a building-stone; also for lintels and door-posts, and can be formed into water-troughs. It forms an indifferent paving-stone.

7. Adhesive Slate *Jameson.*—Klebschiefer, *Werner.*

External Characters.—Colours grey and white. Massive. Dull. Fractur. straight slaty; thick or thin slaty. Fragments tabular. Soft, passing into very soft. Sectile. Feels somewhat greasy. Adheres strongly to the tongue. Specific gravity, 2.080, *Klaproth.*

Chemical Character.—Infusible before the blowpipe.

Constit. Parts.—	Silica,	58.0
	Alumina,	5.0
	Magnesia,	6.5
	Lime,	1.5
	Iron and Manganese,	9.0
	Water,	19.9—100.

Bucholz.

Geognostic Situation.—It occurs in beds in secondary gypsum, and contains imbedded menilite.

Geographic Situation.—It has hitherto been found only in the gypsum formation around Paris.

8. Polier. or Polishing Slate, *Jameson.*—Polierschiefer, *Werner.*

External Characters.—Colours white, grey, brown, and yellow. Occurs massive. Dull. Principal fracture straight and thin slaty; cross fracture fine earthy. Opaque. Soils slightly. Very soft, passing into friable. Uncommonly easily frangible. Feels fine, but meagre. Specific gravity, 0.590—0.606, *Haberle.*

Constituent Parts.	Silica,	79.0
	Alumina,	1 00
	Lime,	1.00
	Oxide of iron,	4.00
	Water,	14.00—99.00

Bucholz, in Journ. fur d. Chemie et Physik, b. ii. s. 28.

Geognostic and Geographic Situations.—It forms a bed in the neighbourhood of rocks of the coal-formation, at Planitz in Saxony.

IX. Tripoli, *Jameson.* Tripel, Werner.

External Characters.—Colours grey, white, and yellow. Occurs massive, and in whole beds. Dull. Fracture sometimes fine, sometimes coarse earthy, and in the great inclines to slaty. Opaque. Soft, sometimes passing into very soft. Not very brittle, and rather easily frangible. Feels meagre, and rather rough. Does not adhere to the tongue. Specific gravity 2.202, *Bucholz.*

Chemical Character. It is infusible before the blowpipe.

		Rottenstone.
Constituent Parts.	Silica,	4
	Alumina,	86
	Carbon,	10—100

Phillips.

Geognostic Situation. It occurs in beds in coal-fields; also in beds along with secondary limestone, and alternating with clay, under basalt.

Geographic Situation. It is found at Bakewell in Derbyshire, where it is named *Rottenstone*, and in many other parts of the world

Uses. On account of the hardness of its particles, it is used for polishing stones, metals, and glasses.

** Lithomarge Family.

I. Lithomarge. *Jameson.*—Steinmark, *Werner.*

External Characters—Colours white, grey, blue, and yellow. Occurs massive, disseminated, and globular or amygdaloidal. Dull. Fracture fine earthy in the small, and large conchoidal, and sometimes even, in the great. Fragments indeterminate angular, and rather blunt-edged. Opaque. Becomes shining in the streak. Very soft, sectile, and easily frangible. Adheres strongly to the tongue. Feels fine and greasy. Specific gravity, 2 419. *Kopp.*—2.435 —2.492, *Breithaupt.*

Geognostic and Geographic Situations. It occurs in veins in porphyry, gneiss, greywacke, and serpentine:

in drusy cavities in topaz-rock; or nidular, in basalt, amygdaloid, and serpentine; and it is said also in beds, in a coal-formation. It is found in Scotland, England, Germany, &c.

II. Mountain Soap, *Jameson*. Bergseife. *Werner*.

External Characters.—Colour pale brownish-black. Occurs massive. Dull. Fracture fine earthy. Fragments indeterminate angular. Opaque. Becomes shining in the streak. Writes, but does not soil. Very soft, and perfectly sectile. Easily frangible. Adheres strongly to the tongue. Feels very greasy. Light, bordering on rather heavy.

Geognostic and Geographic Situations. It occurs in trap-rocks in the island of Skye.

Use.—It is valued by painters as a crayon.

III. Yellow Earth. *Jameson*. Gelberde, *Werner*. Argile ocreuse jaune graphique, *Hauy*.

External Characters.—Colour ochre-yellow, of different degrees of intensity. Occurs massive. Dull on the cross fracture, but glimmering on the principal fracture. Fracture in the large inclines to slaty; in the small, it is earthy. Fragments tabular, or indeterminate angular. Becomes somewhat shining in the streak. Opaque. Soils and writes slightly. Very soft, passing into friable. Easily frangible. Adheres pretty strongly to the tongue. Feels rather greasy. Specific gravity, 2.240, *Breithaupt*.

Geognostic and Geographic Situations.—It is found at Wehraw, in Upper Lusatia, where it is associated with clay, and clay ironstone.

Uses.—It may be employed as a yellow pigment; and when burnt, it is sold by the Dutch under the name of *English red*. The remains in Pompeii show that it was used as a pigment, both in its yellow and red state, by the ancient Romans. It appears to have been known to Theophrastus as a yellow pigment.

VI. Bole* *Jameson*. Bol, *Werner*.

External Characters.—Colours brown, yellow, and very rarely pale flesh-red, and brownish-black. Sometimes spotted and dendritic. Massive, and disseminated. Internally lustre glimmering, and very rarely dull. Fracture perfect conchoidal. Red variety feebly translucent, the yellow translucent on the edges, and the brown and the black opaque. Very soft, approaching to soft. Rather sectile, and very easily frangible. Feels greasy. Becomes shining and resinous in the streak. Adheres to the tongue. Specific gravity, 1.922, *Karsten*.—From 1 4 to 2 00, *Kirwan*. 1.777, 2.051, *Breithaupt*.

Chemical Characters. When immersed in water, it breaks in pieces with an audible noise, with the evolution of air-bubbles, and falls into powder. Before the blowpipe, it melts into a greenish-grey coloured slag.

Geognostic Situation. The geognostic situation of this mineral is rather circumscribed, it having been hitherto observed only in secondary or flœtz trap-rocks, principally in trap-tuff, wacke, and basalt, in which it occurs in angular pieces, and disseminated.

Geographic Situation. It is found at Strigau in Silesia, and in other places.

Uses.—It was formerly an article of the Materia Medica, and used as an astringent, and in some places is still employed in veterinary practice. It is said that tobacco-pipes are sometimes made of bole, and that it is an ingredient in the glaze of some kinds of earthen ware.

Genus VIII. AUGITE.

Prismatic. Hardness = 4.5,—7. If above 6, the Sp. gr. = 3.2 and more. Sp. gr. = 2 7—3.5. Below 3.2 is easily cleavable according to an oblique prism. No metallic pearly lustre.

This genus contains four species, viz. 1. Oblique-edged Augite. 2. Straight-edged Augite. 3. Prismatoidal Augite 4. Prismatic augite.

I. Oblique-edged Augite, *Jameson*.—Schiefkantiger Augit, *Mohs*.

Prism = 92° 18′. Cleavage indeterminate diagonal. Hardness = 5.0—6.0. Sp. gr. = 3.2 —3.5.

This species contains seven subspecies, viz. Foliated Augite, Granular Augite, Conchoidal Augite, Common Augite, Coccolite, Diopside, and Sahlite.

First Subspecies.

Foliated Augite, *Jameson*.—Blættriger Augit, *Werner*.

External Characters.—Colours black and green. Crystallized in six-sided prisms, bevelled on the extremities, and also in twin crystals. Internally it is shining, inclining to splendent, and the lustre resino-vitreous. Fracture conchoidal. Opaque, or translucent on the edges.

Chemical Characters.—Fusible with difficulty into a black enamel.

		From Ætna.
Constituent Parts.—	Silica, . .	52 00
	Alumina, . .	3.33
	Magnesia, .	10.00
	Lime, . .	13.20
	Oxide of Iron,	14.66
	Oxide of Manganese,	2 00—95.19

Vauquelin, Journ. de Min. N. 39. p. 176.

Geographic Situation.—Occurs only in secondary trap-rocks, and in lava.

Geographic Situation.—It is found in basalt in different districts in Scotland, and abundantly on the continent.

Second Subspecies.

Granular Augite, *Jameson*.—Körniger Augit, *Werner*.

External Characters.—Colour greenish-black. Occurs massive, in coarse and small angulo-granular concretions. Also crystallized in broad six-sided prisms, bevelled or acuminated on the extremities. Surface rough and glistening. Internally glistening and resinous. Fracture uneven. Opaque.

Geognostic and Geographic Situations.—This subspecies of augite has been hitherto found only in primitive rocks at Arendal in Norway, in several of the iron-mines, particularly that named Ulve-Grube.

Third Subspecies.

Conchoidal Augite, *Jameson*.—Muschlicher Augit, *Werner*

External Characters.—Colours black, green, and sometimes even liver-brown. Occurs in imbedded grains. Lustre splendent, and resino-vitreous. Fracture imperfect, and flat conchoidal. Translucent on the edges, or translucent. Agrees in its other characters with the foregoing subspecies.

Geognostic and Geographic Situations.—It occurs only in secondary trap-rocks, and is the rarest of the subspecies of this species. The finest specimens, from two to three inches in diameter, are found in the vesicular basalt of Fulda.

Fourth Subspecies.

Common Augite, *Jameson*. Gemeiner Augit, *Werner*.

External Characters.—Colours blackish-green and velvet-black. Occurs in large and small imbedded grains. Internally its lustre is intermediate between shining and glistening, and is resinous. Fracture coarse, and small-grained uneven. Sometimes inclining to imperfect conchoidal. Translucent on the edges, seldom translucent. Its other characters agree with the foliated subspecies.

Geognostic and Geographic Situations.—It occurs principally in secondary trap-rocks, as basalt and greenstone, and also in lavas. The secondary trap-rocks of France, Germany, and Britain, and the lavas of Vesuvius and Iceland, in many cases abound with this mineral.

Fifth Subspecies.

Coccolite, *Jameson*.—Kokkolith, *Werner*.

External Characters.—Colour green. Occurs massive, also in granular concretions. Sometimes crystallized in the same form as the other subspecies. Internally shining, sometimes approaching to glistening, and lustre vitreous, inclining to resinous. Fracture uneven. Translucent, or translucent on the edges.

Geognostic Situation.—It occurs in mineral beds subordinate to the primitive trap formation, where it is associated with granular limestone, garnet, and magnetic iron-ore.

Geographic Situation.—It occurs at Arendal in Norway; in the iron mines of Hellsta and Assebro in Sudermanland; and in many places in Nericke, in Sweden.

Sixth Subspecies.

Diopside, *Jameson*.—Diopsid, *Werner*.

External Characters.—Colours greenish-white, greenish-grey, and pale mountain-green. Occurs massive, disseminated, in lamellar concretions, which sometimes approach to prismatic; and crystallized in low, oblique four-sided prisms, and also in six and eight-sided prisms. Externally shining, glistening, and pearly; internally shining and vitreous. Fracture uneven, sometimes inclining to imperfect and small conchoidal. Translucent.

Geognostic and Geographic Situations.—It is found in the hill of Ciarmetta in Piedmont; also in the Black Rock at Mussa, near the town of Ala, in veins, along with epidote or pistacite, and hyacinth-red garnets; and in the same district, in a vein traversing serpentine, along with prehnite, calcareous-spar, and iron-glance or specular iron-ore.

Seventh Subspecies.

Sahlite, *Jameson*.—Sahlit, *Werner*.

External Characters.—Colour green. Occurs massive, and in straight lameller and coarse granular concretions; also crystallized in four-sided prisms. Internally the lustre of the principal fracture is shining, splendent and vitreous; that of the cross fracture dull. Fracture uneven. Translucent on the edges.

Geognostic and Geographic Situations.—It occurs in the island of Unst in Shetland; in granular limestone in the island of Tirec, one of the Hebrides; in limestone in Glen Tilt; in Rannoch; in the silver mines of Sala, in Westmanland in Sweden, associated with asbestous actynolite, calcareous-spar, iron-pyrites, and galena; near Arendal in Norway, along with magnetic iron-ore, common hornblende, calcareous-spar, and seldom with felspar and black mica. Some of the varieties of asbestus and actynolite of authors belong to augite, particularly those varieties met with in secondary trap rocks.

2. Straight-Edged Augite, *Jameson*.—Rechtkantiger Augit, *Mohs*.

Prism = 124° 34′. Cleavage indeterminate diagonal. Hardness = 5.0—6.0. Sp. gr. = 2.7—3.2.

This species contains five subspecies, viz. Carinthin, Hornblende, Actynolite, Tremolite, and Asbestus.

First Subspecies.

Carinthin, *Jameson*.—Karinthin, *Werner*.

External Characters.—Colour black. Occurs massive and disseminated; and the massive varieties in coarse granular concretions. Internally splendent, and lustre resino-vitreous. Fracture conchoidal. Greenish-black varieties are strongly translucent on the edges, but the velvet-black opaque.

Geognostic and Geographic Situation.—It occurs in the Saualpe in Carinthia, in a bed in primitive rock, associated with quartz, kyanite, garnet, and zoisite.

Second Subspecies.

Hornblende, *Jameson*.—Hornblende, *Werner*.

This species is divided into three kinds, viz. Common Hornblende, Hornblende-Slate, and Basaltic Hornblende.

First Kind.—Common Hornblende, *Jameson*.—Gemeiner Hornblende, *Werner*.

External Characters.—Colours black and green. Occurs massive, disseminated, and in granular concretions. Rarely crystallized in oblique four-sided prisms, and also in six-sided prisms. Internally the lustre is shining and pearly. Fracture coarse and small grained uneven. Black coloured varieties opaque, but the green generally translucent on the edges. Yields a mountain-green, inclining to a greenish-grey coloured streak. When breathed on or moistened, even when brought from a colder to a warmer place, it yields what is called a bitter smell.

Chemical Characters.—It melts before the blowpipe, with violent ebullition, into greyish-black coloured glass.

Common Hornblende from Nora in Westmanland.

Const. Parts.—	Silica,	42.00	
	Alumina,	12.00	
	Lime,	11.00	
	Magnesia,	2.25	
	Oxide of Iron,	30.00	
	Ferruginous manganese,	0.25	
	Water,	0.75	
	Trace of Potash,		98.25

Klaproth, Beit. b. v. s. 153.

Geognostic Situation.—It occurs in great abundance in primitive rocks, and also in some rocks of the secondary class.

Geographic Situation.—It occurs very abundantly in Scotland, in greenstone and syenite; and imbedded in limestone, gneiss, and mica-slate. It is found in similar rocks in England; and plentifully in the primitive traprocks of Ireland.

Second Kind.—Horneblende-Slate, *Jameson*.—Hornblende Schiefer *Werner*.

External Characters.—Colour green. Occurs massive, and in thin promiscuous prismatic concretions. Internally glistening, passing into shining and pearly. Fracture straight slaty. Opaque. Yields a greenish-grey coloured streak.

Geognostic Situation.—It occurs in beds, in granite, gneiss, mica-slate, quartz-rock, sometimes also in clay-slate, and frequently along with beds of primitive limestone.

Geographic Situations.—In Scotland, it occurs in gneiss, in the districts of Braemar and Aberdeen, in Aberdeenshire; in Banffshire, as near Portsoy; in Argyleshire, as in the islands of Coll, Tiree, &c.; in Inverness-shire, as in the islands of Rona, Lewis, &c.; and in many other parts in Scotland; and also in England and Ireland.

Third Kind.—BASALTIC HORNBLENDE, *Jameson.*—Basaltische Hornblende, *Werner.*

External Characters.—Colour black. Occurs crystallized, in six-sided prisms, variously modified. Lustre of cleavage splendent and vitreous, approaching to pearly; that of the cross fracture glistening. Fracture small-grained uneven, approaching to conchoidal. Opaque. Rather harder than common hornblende. Affords a dark greyish-white streak.

Geognostic and Geographic Situation.—It occurs imbedded in trap-rocks in Scotland, and other countries.

THIRD SUBSPECIES.

ACTYNOLITE, *Jameson.*—Strahlstein, *Werner.*

This subspecies is divided into three kinds, viz. Asbestous Actynolite, Common Actynolite, and Glassy Actynolite.

First Kind.—ASBESTOUS ACTYNOLITE, *Jameson.*—Asbestartiger Strahlstein, *Werner.*

External Characters.—Colours grey, green, blue, and brown. Occurs massive, in distinct concretions, which are fibrous, and sometimes collected into others which are wedge-shaped and granular. Rarely occurs crystallized, in delicate capillary, rigid, moss-like, superimposed crystals. Internally the lustre is glistening and pearly. Opaque, or slightly translucent on the edges. Fibres or concretions in groups are soft, but individually equally hard with the other varieties of actynolite.

Geognostic Situation.—It occurs in beds in gneiss, mica-slate, and granular limestone.

Geographic Situation.—In Scotland, also in Norway, Sweden, &c.

Second Kind.—COMMON ACTYNOLITE.—*Jameson.*—Gemeiner Strahlstein, *Werner.*

External Characters.—Colour green. Occurs massive and disseminated; also in wedge-shaped prismatic concretions, which are scopiform, stellular, and promiscuous; these sometimes pass into angulo-granular concretions. Frequently the prismatic concretions are collected into large granular concretions. Internally shining, inclining to glistening, and pearly inclining to vitreous. Fracture uneven and conchoidal. Generally translucent on the edges.

Geognostic Situation.—It occurs in beds in gneiss, mica-slate, and talc-slate.

Geographic Situation.—It occurs at Eilan Reach in Glenelg, in Inverness-shire; near Fortrose in Cromarty; in the parish of Sleat, in the isle of Skye; different places in the isle of Lewis.

Third Kind.—GLASSY ACTYNOLITE, *Jameson.*—Glasartiger Strahlstein, *Werner.*

External Characters.—Colour green. Occurs massive: also in prismatic distinct concretions, which are fibrous, or radiated, arranged in a scopiform, and rarely in a promiscuous manner; and these are again collected into wedge-shaped prismatic or granular concretions. Internally shining, sometimes splendent, and intermediate between vitreous and pearly. Translucent or semi-transparent. Brittle. Uncommonly easily frangible. Traversed by numerous parallel rents.

Geognostic and Geographic Situations.—It occurs in primitive rocks in the isle of Skye, and other parts of Scotland.

FOURTH SUBSPECIES.

TREMOLITE, *Jameson.*—Tremolith, *Werner.*

This subspecies is divided into three kinds, viz. Asbestous Tremolite, Common Tremolite, and Glassy Tremolite.

First Kind.—ASBESTOUS TREMOLITE, *Jameson.* Asbestartiger Tremolit, *Werner.*

External Characters.—Most common colour greyish-white; it is also yellowish-white, greenish-white, rarely reddish-white, and pale violet blue. Occurs massive; also in fibrous or very thin prismatic distinct concretions. Internally shining, approaching to glistening, and pearly. Translucent on the edges. Rather easily frangible.

Geognostic Situation.—It occurs most frequently in granular foliated limestone, or in dolomite; sometimes in chlorite; and more rarely in secondary trap-rocks.

Geographic Situation.—It occurs in foliated granular limestone in Glen Tilt, in Perthshire, and in Glen Elg in Inverness-shire; in dolomite in Aberdeenshire and Icolmkill; in the Shetland Islands; and in basalt in the Castle Rock of Edinburgh.

Second Kind.—COMMON TREMOLITE, *Jameson.*—Gemeiner Tremolit, *Werner.*

External Characters.—Most frequent colour white, seldom grey, pale asparagus-green, and blue. Occurs massive; also in distinct concretions, which are prismatic, and these are collected into longish granular concretions. Sometimes crystallized in oblique four-sided prisms. Lustre shining, and intermediate between vitreous and pearly. Fracture uneven or conchoidal. Translucent or semi-transparent. Rather brittle. Easily frangible. Powder rough to the feel.

Geognostic Situation.—Like the asbestous subspecies occurs principally in granular limestone, or dolomite, and in metalliferous beds.

Geographic Situation.—It occurs in Glen Tilt, Glen Elg, and in the Shetland Islands; also at Clicker Tor in Cornwall.

Third Kind.—GLASSY TREMOLITE, *Jameson.*—Glasartiger Tremolith, *Werner.*

External Characters.—Colour white. Occurs massive; also in distinct concretions, which are straight and scopiform prismatic, with numerous cross rents, and these are again grouped into thick and wedge-shaped concretions. Frequently crystallized in long acicular crystals. Lustre shining, but in a lower degree than the preceding subspecies, and intermediate between vitreous and pearly. Translucent.

Geognostic Situation.—It is the same as that of the preceding subspecies, occurring principally along with granular limestone.

Geographic Situation.—In Scotland it occurs along with the other kinds.

FIFTH SUBSPECIES.

ASBESTUS, *Jameson.* Asbest, *Werner.*

This subspecies is divided into four kinds, viz. Rock-Cork, Amianthus, Common Asbestus, and Rock-wood.

First Kind. ROCK-CORK, *Jameson.* Berg Cork, *Werner.*

External Characters.—Colours white, grey, and yellow. Occurs massive, in plates that vary in thickness, corroded, and with impressions; and these forms are composed of delicate and promiscuous fibrous concretions. Internally feebly glimmering, or dull. Fracture fine grained uneven, inclining to slaty in the large. Opaque. Very soft. Becomes shining in the streak. Sectile, almost like common cork. Slightly elastic flexible. Difficultly frangible. Adheres slightly to the tongue. Emits a grating sound when we handle it. Feels meagre. So light as to swim on water. Specific gravity, 0.679, 0.991, *Brisson.*—0.991, *Hauy.*

Chemical Characters.—It melts with great difficulty before the blowpipe into a milk-white nearly translucent glass.

Geognostic Situation.—It occurs in cotemporaneous veins in serpentine, and in red sandstone; also in metalliferous veins in primitive and transition rocks; and occasionally in mineral beds.

Geographic Situation.—It occurs in veins in the serpentine of Portsoy, and in the red sandstone of Kincardineshire; in plates, in the lead-veins at Lead Hills and Wanlockhead in Lanarkshire; and in small quantities at Kildrummie in Aberdeenshire.

Second Kind. AMIANTHUS, or FLEXIBLE ASBESTUS, *Jameson.* Amiant, *Werner.*

External Characters.—Colours white, grey, blue, and green. Sometimes blood red, particularly when it occurs in veins in serpentine. Occurs in fibrous distinct concretions. Internally lustre shining and pearly. Translucent on the edges, or opaque. Very soft. Perfectly flexible.

Geognostic Situation.—It occurs frequently along with common asbestus, in cotemporaneous veins in serpentine.

Geographic Situation.—It occurs in serpentine in the islands of Mainland, Unst, and Fetlar in Shetland; and in the same rock at Portsoy.

Uses.—This mineral, on account of its flexibility, and its resisting the action of considerable degrees of heat, was woven into those incombustible cloths, in which the ancients sometimes wrapped the bodies of persons of distinction before they were placed on the funeral pile, that their ashes might be collected free from admixture.

Third Kind. COMMON ASBESTUS, *Jameson.* Gemeiner Asbest, *Werner.*

External Characters.—Colours dark leek-green, and mountain-green; also greenish-grey and yellowish-grey. Occurs massive; and in fibrous distinct concretions. Internally glistening and pearly. Fracture not visible. Translucent, or only translucent on the edges. Soft, approaching to very soft. Rigid or inflexible. Rather brittle. Difficultly frangible. Feels rather greasy. Specific gravity, 2.000, *Karsten.*—2.542, *Kirwan.*—2.591, *Breithaupt.*

Geognostic Situation.—Like amianthus, it occurs in veins in serpentine, and in primitive greenstone.

Geographic Situation.—It occurs in the serpentine of Shetland, Long Island, Portsoy, Anglesey, and Cornwall.

Fourth Kind. ROCK WOOD, or LIGNEOUS ASBESTUS, *Jameson.*—Bergholz, *Werner.*

External Characters.—Colour wood-brown, of various degrees of intensity. Occurs massive, and in plates; also in delicate and promiscuous fibrous concretions. Internally lustre glimmering. Fracture curved slaty. Becomes shining in the streak. Soft, passing into very soft. Opaque. Sectile. Specific gravity, before immersion, 1.534; after immersion, 2.225, *Breithaupt.*

Chemical Characters.—Is infusible before the blowpipe.

Geognostic and Geographic Situations.—It occurs at Sterzing in the Tyrol, in primitive rocks.

3. PRISMATOIDAL AUGITE, *Jameson.* Prismatoidischer Augit, *Mohs.*

Prism =114° 37′. Cleavage sometimes prismatoidal. Hardness =60.70. Specific gravity =3.2,—3.5.

This species contains two subspecies, viz. Epidote and Zoisite.

FIRST SUBSPECIES.

EPIDOTE or PISTACITE, *Jameson.* Epidote, *Hauy.* Pistazit, *Werner.*

External Characters.—Colours green and black. Occurs massive; also in distinct concretions, which are granular and fibrous, which latter are collected into wedge-shaped prismatic concretions. Frequently crystallized in oblique four-sided, and also in six-sided prisms. Externally the lustre alternates from splendent to glistening, and is vitreous; internally it is shining or glistening, and is resinous, inclining to pearly. Fracture conchoidal, sometimes uneven, sometimes even or splintery. Alternates from translucent to translucent on the edges, and to nearly transparent.

Chemical Characters.—Before the blowpipe it is converted into a brown-coloured scoria, which blackens by continuance of the heat.

		Epidote from the Valais.
Constituent Parts.—	Silica . .	37.0
	Alumina .	26.0
	Lime . .	20.0
	Oxide of iron .	13.0
	Oxide of manganese	0.6
	Water . .	1.8
	Loss . .	1.0—100.0

Geognostic Situation.—Occurs in beds and veins, and sometimes as an accidental constituent part of rocks.

Geographic Situation.—In Arran it occurs in syenite and clay-slate; in Mainland in Shetland in syenite, and in other districts in Scotland.

SECOND SUBSPECIES.

ZOISITE, *Jameson.*

This subspecies is divided into two kinds, viz. Common Zoisite and Friable Zoisite.

First Kind.—COMMON ZOISITE, *Jameson.* Zoisite, *Werner.*

External Characters.—Colour grey. Occurs massive; also in large prismatic distinct concretions. Internally it is shining on the cleavage, and glistening on the fracture surface, and the lustre is resino-pearly. Fracture small-grained uneven. Feebly translucent, or only translucent on the edges.

Geognostic and Geographic Situations.—It was first observed in the Saualp in Carinthia; and we have it from Glen Elg in Inverness-shire, and from Shetland.

Second Kind.—Friable Zoisite, *Jameson.* Mürber Zoisit, Karsten.

External Characters.—Colour reddish white, which is spotted with pale peach-blossom red. Massive, and in very fine loosely aggregated granular concretions. Very feebly glimmering. Fracture intermediate between earthy and splintery. Translucent on the edges.

Geognostic and Geographic Situations.—It occurs imbedded in green talk at Radelgraben in Carinthia.

4. Prismatic Augite, or Tabular Spar, *Jameson.* Prismatischer Augitspath, *Mohs.* Schaalstein, *Werner.* Tafelspath, *Karsten.*

Prism =105°. Cleavage indeterminate diagonal. Hardness =4.5—5.0. Sp. gr. =2.7—2.9.

External Characters.—Colour white. Occurs massive, and coarsely disseminated; also in granular and lamellar distinct concretions. Internally the lustre varies from shining to glistening, and is pearly inclining to vitreous. Fracture splintery. Translucent. Brittle, and easily frangible.

Constituent Parts.—Silica,	. . .	50
Lime,	. . .	45
Water,	. . .	5—100

Klaproth, Beit. b. iii. s. 291.

Geognostic and Geographic Situations.—Europe. It occurs in primitive rocks at Orawicza in the Bannat of Temeswar, where it is associated with brown garnets, blue-coloured calcareous-spar, tremolite, actynolite, and variegated copper-ore.

Asia.—It has been lately discovered in the island of Ceylon, associated with cinnamon-stone, in gneiss.

Genus IX. AZURE-SPAR.

Lazur Spath, *Mohs.*

Three axes. Cleavage prismatic and prismatoidal. Blue. Hardness=5,0.0—6.5. Sp. gr.=2.7—3.1.

This genus contains four species, viz. Prismatic Azure-spar, Prismatoidal Azure spar, Dodecahedral Azure-spar, and Calaite.

1. Prismatic Azure-Spar, *Jameson.*—Prismatischer Lazur Spath, *Mohs.*

Pyramid unknown. Cleavage prismatic. Lively Blue colour. Hardness=5.0—5.5. This species contains two subspecies, viz. Azurite and Häuyne.

First Subspecies.

Azurite, *Jameson.*—Lazulit, *Werner.*

External Characters.—Colour blue. Occurs in small massive portions, disseminated, and crystallized in very oblique four-sided prisms, which are rather flatly acuminated on the extremities, with four planes, which are set on the lateral edges. Fracture uneven. Opaque, or very feebly translucent on the edges.

Geognostic Situation.—It occurs imbedded in small portions in quartz: also in fissures in clay-slate, along with sparry-iron. heavy-spar, and quartz.

Geographic Situation.—It occurs principally in the district of Vorau in Stiria.

Second Subspecies.

Hauyne, *Jameson.*—Hauyn. *Karsten.*

External Characters.—Colour blue. Occurs in imbedded grains; rarely crystallized. Externally and internally alternates from splendent to glistening, and lustre vitreous. Has a quintuple cleavage. Fracture imperfect conchoidal. Transparent and translucent. Brittle. Very easily frangible. Scratches glass. Sp. gr. 2.687.

Geognostic and Geographic Situations.—It occurs imbedded in the basalt rocks of Albano and Frascati, along with mica, augite, leucite, and vesuvian; also in the basalt of Andernach.

2. Prismatoidal Azure-Spar, or Blue Spar, *Jameson.*—Prismatoidischer Lazur Spath, *Mohs.* Blauspath, *Werner.*

Pyramid unknown. Cleavage prismatoidal. Pale colours. Hardness=5.5—6.0.

External Characters.—Colour pale smalt-blue, which sometimes passes into sky-blue, and occasionally into milk-white. Occurs massive and disseminated. Internally glistening, approaching to shining. Fracture splintery. Translucent in a low degree. Yields a greyish-white coloured streak.

Chemical Characters.—Before the blowpipe it becomes white and opaque; and affords a black-coloured glass with borax.

Constituent Parts.—Silica,	. .	14.00
Alumina,	.	71.00
Magnesia,	.	5.00
Lime,	. .	3.00
Potash,	. .	0.26
Oxide of Iron,		0.75
Water,	. .	5.00—99.00

Klaproth, Beit. b. iv. s. 85.

Geognostic and Geographic Situations.—It occurs along with quartz, mica, and garnets, in the valley of Murz, near Krieglach, in Stiria.

3. Dodecahedral Azure-Spar or Lapis Lazuli, *Jameson.*—Lasursstein, *Werner.*

Tessular. Dodecahedral. Azure blue. Hardness=5.5—6.0. Sp. gr.=2 95.

External Characters.—Colour azure-blue, of all degrees of intensity. Found massive, disseminated, in rolled pieces, and in rhomboidal dodecahedrons. Internally either glistening or glimmering. Fracture uneven. Feebly translucent on the edges.

Constit. Parts.—Silica,	. . .	46.00
Alumina,	. .	14.50
Carbonate of Lime,	.	28.00
Sulphate of Lime,	.	5.50
Oxide of Iron,	.	3.00
Water,	. . .	2.00—100

Klaproth, b. i. s. 196.

Geognostic and Geographic Situations.—It occurs in primitive limestone, along with iron-pyrites, in Persia, Tartary, and China; in veins that traverse granite, along with quartz, mica, and iron-pyrites, in the Altain mountains; and at the southern end of the Lake Baikal in Siberia, in a vein, associated with garnets, mica, felspar, and iron-pyrites.

Uses.—On account of its beautiful blue colour, and the fine polish it is capable of receiving, it is much prized by lapidaries, and is cut into various ornamental articles. It is highly valued by painters, on account of the fine ultramarine blue colour obtained from it.

4. Calaite, or Mineral Turquois, *Jameson and Fischer.*

External Characters.—Colours blue and green. Occurs massive, disseminated, reniform, and botryoidal. Internally dull, or feebly glistening and resinous. Fracture imperfect conchoidal, or coarse-grained unoven. Opaque. Harder than felspar, but softer than quartz. Streak white. Specific gravity 2.860, 3.0, *Fischer*.

Constituent Parts.—Alumina,	. .	73
Oxide of Copper,		4.50
Water,	. .	18
Oxide of Iron,	.	4.
Loss,	. .	0.50—100.

John, in Fischer's Essai sur la Turquoise, p. 27.

Geognostic Situation.—It occurs in veins in clay ironstone, and also in small pieces in alluvial clay.

Geographic Situation.—It has hitherto been found only in the neighbourhood of Nichabour in the Khorasan in Persia.

Uses.—It is very highly prized as an ornamental stone in Persia and the neighbouring countries.

Order VI.—GEM.

No metallic lustre. Streak white. Hardness ranges from 5.5 to 10.0. At and below 6, the specific gravity is equal to 2.4 and less, and amorphous. The specific gravity ranges from 1.9 to 4.7.

Genus I.—BORACITE.

Many axes. Cleavage tessular. Hardness=7.0. Sp. gr.=2.8—3.0.

I. Hexahedral Boracite, *Jameson.*—Boracite, *Werner.*—Hexaedrischer Boracit, *Mohs.*

Tessular. Cleavage octahedral.

External Characters.—Colours white and grey. Occurs crystallized, in cubes, rhomboidal dodecahedrons, and tetrahedrons. Internally shining and adamantine. Fracture imperfect conchoidal. Translucent, and rarely transparent.

Physical Characters.—It is pyro-electric on all the angles, those that are diagonally opposite, being the one positive, and the other negative. This electricity is uncommonly easily excited, even more so than in tourmaline, or indeed in any other mineral with which we are acquainted.

Chemical Characters.—Fusible with ebullition into a yellowish enamel.

	From Segeberg.	From Luneberg.
Const. Parts.—Magnesia,	36.3	16.6
Boracic Acid,	63.7—100	83.4—100.0
	Pfaff.	*Vauquelin.*

Geognostic and Geographic Situations.—This curious mineral has been hitherto found only in the Kalkberg, at Luneberg in Hanover, where it occurs in a particular bed of gypsum, along with imbedded quartz crystals; and in the same formation, in the Segeberg, near Kiel in Holstein.

Genus II.—ANDALUSITE.

Three axes. Cleavage prismatic, slightly oblique. Hardness=7.5. Sp. gr.=3.0—3.2.

I. Prismatic Andalusite, *Jameson.* Prismatischer Andalusit, *Mohs.*

Prismatic. Pyramid unknown. Cleavage indeterminate diagonal.

First Subspecies.

Common Andalusite, *Jameson.*—Andalusit, *Werner.* Feldspath, Apyre, *Hauy.*

External Characters.—Colour flesh-red, which sometimes inclines to pearl-grey. Occurs massive, and crystallized in slightly oblique four-sided prisms, in which the terminal angles and lateral edges are sometimes truncated. Principal fracture shining, in a low degree; cross fracture glistening, and lustre vitreous. Fracture uneven. Feebly translucent.

Chemical Characters.—It becomes white before the blowpipe, but does not melt.

Constituent Parts.—Silica,	. . .	32
Alumina,	. .	52
Potash,	. .	8
Oxide of Iron,	.	2—94
		Vauquelin.

Geognostic Situation.—It occurs in gneiss, mica-slate, and clay-slate.

Geographic Situation.—It occurs in primitive rocks in Scotland and England.

Second Subspecies.

Saussurite, *Jameson.*

External Characters.—Colours white, grey, and green. Occurs massive, disseminated, and in rolled pieces. Internally dull, or feebly glimmering. Fracture splintery. Faintly translucent on the edges.

Chemical Characters.—Before the blowpipe it melts on the edges and angles, but is not entirely melted.

Geognostic and Geographic Situations.—It occurs in Switzerland and other countries.

Genus III.—CORUNDUM.

One and many axes. Cleavage rhomboidal, prismatic, octahedral. If prismatic, the specific gravity is 3.7 and more, and the hardness 8.5 and more. Hardness=8.0, 9.0. Specific gravity=3 5—4 3.

I. Octahedral Corundum, *Jameson.* Octaedrischer Corund, *Mohs*

Tessular. Cleavage octahedral. Hardness=8. Sp. gr.=3.5—3.8.

This species is subdivided into three subspecies, viz. Automalite, Ceylanite, and Spinel.

First Subspecies.

Automalite, *Jameson.* Authomolite, *Werner.*

External Characters.—Colour green. Crystallized, in octahedrons and tetrahedrons. Externally glistening, and lustre pearly, inclining to semi-metallic. Internally shining on the principal fracture, but glistening on the cross fracture, and the lustre resinous. Fracture flat conchoidal. Opaque, or faintly translucent on the edges.

Chemical Character.—It is infusible before the blowpipe.

Constituent Parts.—Alumina,	. .	42
Silica,	. . .	4
Oxide of zinc,	.	28
Iron,	. . .	5
Sulphur,	. .	17
Undecomposed,	.	3—100

Vauquelin, Annales du Mus. t. vi. p. 33.

Geognostic and Geographic Situations.—It occurs imbedded in talc-slate, along with galena, and has been hitherto found only at Fahlun in Sweden.

Observation.—Appears to be a distinct species.

Second Subspecies.

Ceylanite, *Jameson.* Ceylanit, *Werner.*

External Characters.—Colours green and greyish-black. Occurs crystallized in octahedrons and rhomboidal dodecahedrons. Internally splendent, and lustre vitreous, inclining to semi-metallic. Fracture perfect, and very flat conchoidal. Translucent on the edges.

Geognostic and Geographic Situations.—This mineral was first found in the island of Ceylon, where it occurs in the sand of rivers, along with tourmaline, zircon, sapphire, and iron-sand. It also occurs in the ejected unaltered rocks at Monte Somma, and in other quarters.

Third Subspecies.

Spinel, *Jameson.* Spinell, *Werner.*

External Characters.—Principal colour red; from which there is a transition on the one side into blue, and almost into green; on the other side into yellow and brown, and even into white. The following are its secondary crystallizations:

1. Octahedron. 2. Tetrahedron. 3. Rhomboidal dodecahedron. 4. Various twin crystals.

Externally and internally splendent, and lustre vitreous. Fracture flat conchoidal. Alternates from translucent to transparent, and refracts single. Specific gravity, 3.5, 3.8. *Mohs.*

Chemical Characters.—Infusible before the blowpipe without addition; but is fusible with borax.

Constit. Parts.—Alumina,	. .	82.47
Magnesia,	. .	8.78
Chromic acid,	.	6.18
Loss,	. . .	2.57—100

Vauquelin, J. M. No. 38, p. 89.

Geognostic and Geographic Situations.—*Europe.*—It is found in the gneiss district of Acker in Sudermanland, in a white foliated granular primitive limestone; and in drusy cavities, along with vesuvian and ceylanite, in the ejected foliated granular limestone of Vesuvius.

Asia.—It occurs in the kingdom of Pegu, and at Cannanor in the Mysore country. In the island of Ceylon, so prolific in gems, it is found not only in the sand of rivers, but also imbedded in gneiss.

Uses.—It is an esteemed precious stone, but has neither the hardness nor fire of the red sapphire or oriental ruby.

II. Rhomboidal Corundum, *Jameson.* Rhomboedrischer Corund, *Mohs.*

Rhomboidal. Rhomboid=86° 38′. Cleavage in the direction of the rhomboid, or parallel with the terminal planes of the regular six-sided prism. Hardness=9, Specific gravity=3.8—4.3.

First Subspecies.

Sapphire, *Jameson.* Sapphir, *Werner.*

External Characters.—Blue and red are its principal colours; it occurs also grey, white, green, and yellow. Its crystallizations are six-sided pyramids and six-sided prisms. Internally, lustre splendent and vitreous, sometimes inclining to adamantine. Fracture conchoidal. Alternates from transparent to translucent; and the translucent varieties frequently exhibit a six-rayed opalescence. Refracts double.

	Blue Sapphire.	Red Sapphire, or Oriental Ruby.
Const. Parts.—Alumina,	92.0	90.0
Lime, .	5.25	7.0
Oxide of iron,	1.0	1.2
Loss, . .	1.75	1.8
	100	100
	Chevenix, Phil. Trans. 1802.	*Chevenix*, Phil. Trans. 1802.

Chemical Character.—Infusible before the blowpipe.

Physical Characters.—Becomes electrical by rubbing, and retains its electricity for several hours; but does not become electrical by heating.

Geognostic Situation.—It occurs in alluvial soil, in the vicinity of rocks belonging to the secondary or flœtz-trap formation, and imbedded in gneiss.

Geographic Situation.—It occurs in alluvial soil, in different countries of Europe, but most abundantly in the East, as Ceylon, Pegu, &c.

Uses.—This mineral is, next to diamond, the most valuable of the precious stones. The most highly prized varieties are the crimson and carmine red; these are the *Oriental Ruby* of the jeweller, and, next to the diamond, are the most valuable minerals hitherto discovered. The blue varieties, the *Sapphire* of the jeweller, are next in value to the red. The yellow varieties, the *Oriental Topaz* of the jeweller, are of less value than the blue or true sapphire.

Second Subspecies.

Emery, *Jameson.*—Schmiergel, *Werner.*

External Characters.—Colour intermediate between greyish-black and bluish-grey. Occurs massive and disseminated; and the massive is sometimes intermixed with other minerals. Lustre glistening, passing into glimmering, and adamantine. Fracture fine and small-grained uneven; sometimes splintery. Slightly translucent on the edges.

Geognostic and Geographic Situations.—It is found in talc-slate at Ochsenkopf near Schwartzenberg, and Eibenstock in Saxony. It occurs abundantly in the island of Naxos.

Use.—It is used for polishing hard minerals and metals, and hence is an important article in the arts.

Third Subspecies.

Corundum, *Jameson.*—Korund and Demant-Spath, *Werner.*

External Characters.—Colours white, grey, green, blue, red, and brown. The green, blue, and red colours are generally muddy, and inclining to grey. When cut in a semicircular form, it often presents an opalescent star of six rays. Its principal crystallizations are six-sided prisms and six-sided pyramids. Externally they are dull and rough. Lustre of the cleavage and fracture shining and glistening, and either vitreous inclining to resinous, or pearly inclining to adamantine. Fracture conchoidal, and sometimes uneven. Alternates from strongly translucent to translucent on the edges.

Geognostic and Geographic Situations.—Red and blue corundum occur in dolomite in St. Gothard; also in the Carnatic, on the coast of Malabar; and abundantly in the neighbourhood of Canton in China.

Use.—In its powdered state, it has long been used by the artists of India and China for cutting and polishing precious stones.

III. Prismatic Corundum or Chrysoberyl, *Jameson.* Krysoberyll, *Werner.* Cymophane, *Hauy.* Prismatischer Corund, *Mohs.*

Prismatic. Prism =104° 41′. Cleavage prismatoidal, in the direction of the smaller diagonal of the oblique four-sided prism. Hardness = 8.5. Specific gravity =3.7—3.8.

External Characters.—Chief colour asparagus green. Often exhibits a milk-white opalescence, which appears in general to float in the interior of the mineral. Occurs in blunt angular rolled pieces, that sometimes approach to the cubic form, and crystallized in six-sided prisms. Internally splendent, and lustre intermediate between resinous and vitreous, but more inclining to the first. Fracture perfect conchoidal. Semitransparent, sometimes inclining to transparent, and refracts double.

Constit. Parts.—	Alumina,	71.5
	Silica,	18.0
	Lime,	6.0
	Oxide of iron,	1.5
	Loss,	3.0—100

According to *Klaproth*, b. i. s. 102.

Geognostic and Geographic Situations.—It occurs in Brazil, in alluvial soil with topaz, or in sandstone with diamond; and at Haddam, on Connecticut River, in the United States, in granite, along with garnets, beryl, and tourmaline.

It is found in the island of Ceylon, in the beds of rivers, along with sapphires, rubies and tourmalines.

Uses.—This fine gem was formerly much less prized than it is at present. When cut and polished, it is not inferior in brilliancy and beauty to other gems of the same colour.

Genus IV. DIAMOND.

Tessular. Hardness =10. Sp. gr. =3.4—3.6.

1. Octahedral Diamond, *Jameson.*—Octaedrischer Demant, *Mohs.*

Tessular. Cleavage octahedral.

External Characters.—Most common colours of the diamond are white and grey. Besides these two colours, it occurs blue, red, brown, yellow, and green. Occurs generally crystallized in octahedrons, tetrahedrons, rhomboidal dodecahedrons, and in various twin crystals. Internally, is always splendent, often specular splendent, and the lustre perfectly adamantine. Seldom completely transparent; more generally it rather inclines to semitransparent; but the black variety is nearly opaque. Refracts single.

Constituent Parts.—Is said to be nearly pure carbon.

Geognostic Situation.—It occurs in imbedded grains and crystals, in alluvial soil, sandstone, and, it is said, in secondary trap-rocks.

Geographic Situation.—It occurs in Brazil, Peninsula of India, and the island of Borneo.

Uses.—The diamond, on account of the splendour of its lustre, its peculiar play of colour, its hardness, and, lastly, its rarity, is considered as the most precious substance in the mineral kingdom, and is particularly valued by jewellers. The diamonds purchased by jewellers are generally in grains, or crystals, and sometimes coarsely polished. Vide Article Diamond, for a full account of various sizes of the diamond.

Genus V. TOPAZ.

Prismatic. Axifrangible. Hardness =8. Sp. gr. = 3.4—3.6.

1. Prismatic Topaz, *Jameson.*—Prismatischer Topaz, *Mohs.*

Prismatic. Pyramid =141° 7′: 101° 52′: 90° 55′: Prism =124° 19′. Cleavage axifrangible.

This species contains three subspecies, viz. Common Topaz, Schorlite, and Physalite or Pyrophysalite.

First Subspecies.

Common Topaz. Topaz, *Werner.*

External Characters.—Colours yellow, green, blue, and red. Frequently crystallized, and generally in prisms which are variously bevelled and acuminated. The lateral planes of the crystals are longitudinally streaked; but the acuminating and bevelling planes are smooth; the terminal planes rough. Externally splendent; internally, splendent and vitreous. Fracture small and perfect conchoidal. Alternates from transparent to semitransparent; and refracts double.

Chemical Characters.—Saxon topaz in a gentle heat becomes white, but a strong heat deprives it of lustre and transparency: the Brazilian, on the contrary, by exposure to a high temperature, burns rose-red, and in a still higher violet-blue.

Physical Characters.—When heated, exhibits at one extremity positive, and at the other negative electricity. It also becomes electrical by friction, and retains this property for a considerable time, sometimes more than twenty-four hours.

		Brazilian Topaz.
Const. Parts.—	Alumina,	58.38
	Silica,	34.01
	Fluoric acid,	7.79—100.18

Berzelius, Afhandlingar, vol. iv. p. 236.

Geognostic Situation.—It occurs in various primitive rocks, such as topaz-rock, gneiss, and clay-slate.

Geographic Situation.—It occurs in large crystals, and rolled masses, in an alluvial soil, in the granite and gneiss districts of Mar and Cairngorm, in the upper parts of Aberdeenshire; and in veins, along with tinstone, in clay-slate, at St. Anne's, in Cornwall; also in St. Michael's Mount, and at Trevaunance, in the same county. The finest topazes are those found in Brazil.

Uses.—This gem is much prized by jewellers, and is considered as one of the more beautiful ornamental stones.

Second Subspecies.

Schorlite, or Schorlous Topaz, *Jameson.*—Schorlartiger Berill, or Piknit, *Werner.* Pycnite, *Hauy.*

External Characters.—Colours yellow, white, and grey. Occurs almost always massive, also in parallel, thin, and straight prismatic distinct concretions, which are longitudinally streaked, and crystallized in long six-sided prisms, which are sometimes truncated on the terminal edges and angles, and are generally imbedded. Externally and internally its lustre is shining, approaching to glistening, and is resinous. Fracture small and imperfect conchoidal, or fine-grained uneven. More or less translucent on the edges. Brittle. Uncommonly easily frangible.

Geognostic and Geographic Situations.—It occurs at Altenberg in Saxony, in a rock of quartz and mica which forms an imbedded mass, included in porphyry.

Third Subspecies.

Physalite, or Pyrophysalite. *Jameson.*—Pyrophysalith, *Hisinger.* Physalith, *Werner.*

External Characters.—Colours greenish-white and mountain-green. Massive. Occurs in coarse granular distinct concretions. Lustre of the cleavage splendent, of the cross fracture glistening or dull. Fracture uneven or conchoidal. Translucent on the edges.

Geographic Situation.—It is found imbedded in granite at Finbo, near Fahlun, in Sweden.

Genus VI. EMERALD.

Rhomboidal. Prismatic. Cleavage prismato-rhomboidal, prismatoidal; first axifrangible. Hardness 7.5, 8.0. Sp. gr. =2.6, 3.2.

1. Prismatic Emerald, or Euclase, *Jameson.*—Euclas, *Werner.* Prismatischer Smaragd, *Mohs.*

Prism =133° 26′. Cleavage prismatoidal, in the direction of the smaller diagonal. Hardness=7.5. Sp. gr. =2.9, 3.2.

External Characters.—Colours, white, green, and blue. Crystallized in oblique four-sided prisms variously modified by truncations, and bevelments, and acuminations. Internally splendent. Fracture small conchoidal. Alternates from transparent to translucent, and refracts double.

Chemical Characters.—Before the blowpipe, it first loses its transparency, and then melts into a white enamel.

Const. Parts.—Silica,	.	35
Alumina,	.	18
Glucina,	.	14
Iron,	. .	2
Loss,	. .	31—100. *Vauquelin.*

Geognostic and Geographic Situation.—This rare and beautiful mineral occurs in Peru and Brazil.

2. Rhomboidal Emerald, *Jameson.*—Rhomboedrischer Smaragd, *Mohs.*

Di-rhomboid =138° 35′; 90°. Cleavage most distinct parallel with the terminal planes of the six-sided prism, less distinct in the direction of the lateral planes of the six-sided prism. Hardness =7.5, 8.0 Sp. gr. =2.6, 2.8.

First Subspecies.

Precious Emerald, *Jameson.*—Schmaragd, *Werner.*

External Characters.—Colour emerald green, generally crystallized in equiangular six-sided prisms. Lateral planes smooth; terminal planes rough. Internally lustre intermediate between shining and splendent, and vitreous. Fracture small and imperfect conchoidal. Alternates from transparent to translucent, and refracts double in a moderate degree.

Const. Parts.—Silica,	. .	64.5
Alumina,	. .	16
Glucina,	. .	13
Oxide of Chrome,		3.25
Lime,	. .	1.6
Water,	. .	2.0—100.35

Vauquelin, Jour. des Mines, N. 38, p. 98.

Geognostic Situation.—It occurs in drusy cavities, in veins in clay-slate, and also imbedded in mica-slate; and loose in the sand of rivers and other alluvial deposites.

Geographic Situation.—The most beautiful emeralds are at present brought from Peru; and others of less value are found in Salzburg.

Use.—It is rare to find the colour of this gem pure and of good strength; hence such specimens are very highly valued, and are employed in the most expensive kinds of jewellery. It is valued next to the ruby; and, when of good colour, is set without a foil, and upon a black ground, like brilliant diamonds.

Second Subspecies.

Beryl, *Jameson.*—Edler Beril, *Werner.*

External Characters.—Colours green, blue, and yellow. Occurs massive, and this variety sometimes appears arranged in straight and thin prismatic distinct concretions. Often crystallized in long equiangular six-sided prisms, either perfect, or truncated on the lateral and terminal edges or angles, also sometimes acuminated. Lateral planes deeply longitudinally streaked, but the terminal, acuminating, and truncating planes are smooth. Externally, lustre shining and glistening; internally shining, which sometimes passes into glistening and splendent, and vitreous. Fracture small, and more or less perfect conchoidal. Commonly transparent, and refracts double, but in a feeble degree.

Const. Parts.—Silica,	. .	69.50
Alumina,	. .	14.00
Glucina,	. .	14.00
Oxide of Iron,	.	1.00—98.50

Rose, in Karsten's Tabellen.

Geognostic Situation.—It occurs in veins that traverse granite and gneiss, also imbedded in granite, and dispersed through alluvial soil.

Geographic Situation.—It occurs in alluvial soil along with rock-crystal and topaz, in the upper parts of Aberdeenshire. In Ireland, imbedded in granite, near Lough Bray, in the county of Wicklow, and near Cronebane in the same county.

Uses.—When pure, it is cut into ring-stones, sealstones, brooches, intaglios, and necklaces, but is not so highly valued as emerald.

Genus VII.—IOLITE.

Cleavage rhomboidal. Hardness=7.0—7.5. Sp. gr. =2.5—2.6.

1. Prismato-Rhomboidal Iolite, *Jameson.*—Iolith and Peliom, *Werner.*

Rhomboid unknown. Cleavage in the direction of the lateral planes of the regular six-sided prism.

External Characters.—Colour intermediate between violet-blue and blackish-blue. When viewed in the direction of the axis of the crystals, the colour is dark indigo-blue; but perpendicular to the axis of the crystals, pale brownish-yellow. Occurs massive, disseminated, and rarely crystallized in six-sided prisms.

Internally shining, and the lustre vitreous. Fracture small-grained uneven, and sometimes conchoidal. Translucent in the direction of the axis of the crystal, and transparent at right angles to it. Refracts double.

Const. Parts.—Silica,	. .	43.6
Alumina,	. .	37.6
Magnesia,	. .	9.7
Potash,	. .	1.0
Oxide of Iron,	.	4.5
——— Manganese, a trace		—99.5

Leopold Gmelin.

Geognostic and Geographic Situations.—It is found at Orijarvi, near Abo in Finland; at Bodenmais in Bavaria; in the county of Salzburg; and in other parts of Europe and America.

Use.—It is cut, polished, and worn as a gem.

Genus VII. a. QUARTZ.

Rhomboidal. Cleavage rhomboidal, not axifrangible. Hardness=5 5—7.5. Sp. gr =1.9—2.7.

1. Rhomboidal Quartz, *Jameson.*—Quartz, *Werner.* Rhomboedrischer Quartz, *Mohs.*

Rhomboidal. Rhomboid=76° 2′. Cleavage in the direction of the alternate planes of the double six-sided pyramid, and in the direction of the lateral planes of six-sided prism. Hardness=7.0. Sp gr.=2.5—2.7.

The species contains fourteen subspecies, viz. 1. Amethyst, 2. Rock Crystal, 3. Milk Quartz, 4. Common Quartz, 5. Prase, 6. Cat's-eye, 7. Iron Flint, 8. Hornstone, 9. Flinty Slate, 10. Flint, 11. Calcedony, 12. Heliotrope, 13. Jasper, 14. Floatstone, * Agate.

First Subspecies.

Amethyst.

External Characters.—Colour violet-blue. Occurs massive, and in prismatic and lamellar concretions. Most frequent crystallization is the acute six-sided pyramid; a less frequent form is the six-sided prism with a six-planed acumination. Alternates from translucent to transparent. Internally splendent, or shining, and lustre vitreous. Fracture conchoidal.

Geognostic Situation—It occurs in agate-balls in amygdaloid, greenstone, and porphyry, and in veins in primitive and secondary rocks.

Geographic Situation.—In veins and drusy cavities in secondary greenstone and amygdaloid, in many parts of Scotland. Near Cork in Ireland. In many places on the continents of Europe, Asia, Africa, and America.

Uses.—The most highly valued amethysts are those brought from the continent of India, and the Island of Ceylon. The next in esteem are the Brazilian. When the colour is good, it is cut and polished, and is considered a gem of considerable beauty.

Second Subspecies.

Rock or Mountain Crystal, *Jameson.*—Bergcrystal, *Werner.*

External Characters.—Colours white, brown, yellow, and red. Generally occurs in crystals, which are usually six-sided prisms acuminated, with six planes set on the lateral planes. Externally the crystals are generally splendent or shining. Internally, splendent and vitreous. Fracture almost always perfect conchoidal. Generally transparent.

Chemical Characters.—It is completely infusible before the blowpipe.

Constituent Parts.—Silica,	. .	$99\frac{3}{8}$
Trace of Ferruginous Alumina,		—100

Bucholz, Gehlen's Journ. 1808, p. 150.

Geognostic Situation.—Although rock-crystal occurs more frequently, and in more numerous geognostic relations than amethyst, yet it is not the most common subspecies of quartz. It appears most frequently, and in the largest and most transparent crystals, in primitive rocks, where it occurs in beds, veins, and large drusy cavities.

Geographic Situation.—Crystals of great size and beauty are found in different parts of Scotland; the rock-crystals of the Island of Arran, which occur in drusy cavities in granite, are well known; but the largest and most valuable are found in the district of Cairngorm, in the upper part of Aberdeenshire, where they occur in granite, or in alluvial soil, along with beryl and topaz. On the Continent of Europe it is very widely, and often abundantly distributed, and the same is the case in Asia and America.

Uses.—Rock-crystal is cut and polished as an inferior kind of gem or ornamental stone.

Third Subspecies.

Rose or Milk Quartz, *Jameson.*—Milch Quartz, *Werner.*

External Characters.—Colours rose-red and milk-white. Occurs only massive. Internally shining, sometimes passing to splendent, and vitreous, inclining to resinous. Fracture more or less perfect conchoidal. More or less translucent. The other characters are the same as those of rock-crystal.

Geognostic Situation.—It occurs in masses, included in beds of quartz subordinate to granite and gneiss, and in veins of manganese in granite.

Geographic Situation.—It occurs in primitive rocks in Scotland, Germany, and in Europe, and in various districts in Asia and America.

Uses.—It is employed in jewellery, and the larger masses are cut into vases.

Fourth Subspecies.

Common Quartz, *Jameson.*—Gemeiner Quartz, *Werner.*

External Characters.—Colours white, grey, yellow, brown, red, green, blue, and black. Occurs massive, disseminated, in plates, stalactitic, reniform, botryoidal, globular, specular, corroded, vesicular, ramose, amorphous, cellular, and with impressions. Internally shining, which sometimes borders on glistening, and sometimes approaches to glimmering, and is vitreous. Fracture coarse splintery, and conchoidal. Generally translucent. The other characters the same as those of rock-crystal.

Geognostic Situation.—It is one of the most abundant minerals in nature, and appears in many different geognostic situations. It occurs in primitive, transition, secondary, alluvial, and volcanic rocks, and either as a constituent part of these rocks, or associated with them in the form of beds and veins.

Geographic Situation.—It abounds in all the primitive, transition, secondary, and alluvial districts of Scotland, England, and Ireland; is abundantly distributed throughout the continents of Europe, Asia, Africa, and America.

Uses.—It is employed in the manufacture of glass and artificial gems; also in the preparation of smalt, and as an ingredient in porcelain and different kinds of pottery. The vesicular and corroded variety forms a most excellent millstone, known in commerce under the name of *Buhr-stone.*

Fifth Subspecies.

Prase, *Jameson.*—Prasem, *Werner.*

Colour leek-green. Generally massive, and in prismatic and granular concretions. Sometimes crystallized in same forms as common quartz. Surface of the concretions rough and transversely streaked. Lustre shining, approaching to glistening, and resino-vitreous. Fracture conchoidal, passing into splintery. Translucent.

Geognostic and Geographic Situations.—It occurs in primitive rocks in Scotland, Germany, and other countries. These beds are probably connected with primitive trap.

Uses.—It is sometimes cut and polished as an ornamental stone, but is not highly esteemed.

Sixth Subspecies.

Cat's-eye, *Jameson.*—Katzenauge, *Werner.*

External Characters.—Principal colours grey, red, and brown. Exhibits a beautiful opalescence, particularly when cut in a convex form. Massive. Internally shining, lustre vitreo-resinous. Fracture conchoidal. Translucent, or translucent on the edges.

Geognostic and Geographic Situations.—It occurs imbedded in gneiss in Ceylon.

Uses.—It is generally cut into ring-stones; and the most advantageous form for displaying its peculiar lustre is the oval, with a convex surface.

Seventh Subspecies.

Iron-Flint, *Jameson.*—Eisenkiesel, *Werner.*

External Characters.—Colours brown and red. Massive and crystallized like common quartz. Usually in granular distinct concretions. Externally lustre shining, approaching to glistening; internally glistening, and vitreo-resinous. Fracture conchoidal. Opaque.

Geognostic Situation.—It occurs in veins of ironstone, and also in trap-rocks.

Geographic Situation.—In rocks near Bristol; in trap-rocks that lie over white limestone, island of Rathlin, off the coast of Ireland; and in trap-rocks near Dunbar in Scotland.

Eighth Subspecies.

Hornstone, *Jameson.*—Hornstein, *Werner.*

There are three kinds, viz. Splintery Hornstone, Conchoidal Hornstone, and Woodstone.

First Kind.—Splintery Hornstone, *Jameson.*—Splittriger Hornstein, *Werner.*

External Characters.—Colours grey, red, and green. Massive. Internally dull. Fracture splintery. More or less translucent on the edges.

Geognostic Situation.—Occurs in veins in primitive rocks.

Geographic Situation.—It occurs in primitive districts in Scotland and England, and in various quarters on the continents of Europe, Asia, and America.

Second Kind.—Conchoidal Hornstone, *Jameson.*—Muschlicher Hornstein, *Werner.*

External Characters.—Colours grey, white, and red. Massive. Internally glimmering, sometimes approaching to glistening, and lustre vitreous. Fracture conchoidal. Translucent, but not in a lower degree than splintery hornstone.

Geognostic Situation.—It occurs in metalliferous veins and agate veins; also, in imbedded portions, in pitchstone porphyry, in striped jasper, and along with claystone porphyry.

Geographic Situation.—It is found along with claystone in the Pentland Hills near Edinburgh; also in Saxony and Bohemia.

Third Kind.—Woodstone, *Jameson.*—Holstein, *Wer.*

External Characters.—Colours grey, red, brown, black, and yellow. Occurs in rolled pieces, and in the shape of trunks, branches, and roots. External surface uneven and rough. Internally dull, sometimes glimmering and glistening, according as it is more or less of the nature of the two preceding subspecies. Cross fracture imperfect conchoidal; the longitudinal fracture splintery and fibrous. Generally translucent on the edges; sometimes feebly translucent.

Geognostic Situation.—It is imbedded in sandy loam in alluvial soil; and it is said also in a kind of sandstone-conglomerate and clay-stone.

Geographic Situation.—It occurs at Loch Neagh in Ireland: at Chemnitz and Hilbersdorf in Upper Saxony, and in many other places.

Ninth Subspecies.

Flinty-Slate, *Jameson.*

Two kinds, viz. Common Flinty-Slate, and Lydian Stone.

First Kind.—Common Flinty-Slate, *Jameson.* Gemeiner Kieselchiefer, *Werner.*

External Characters.—Colours grey, red, and black. Often traversed by quartz veins. Occurs massive. Internally faintly glimmering, almost dull. Fracture in the great slaty, and in the small splintery. More or less translucent, and passes into translucent on the edges.

Geognostic Situation.—It occurs in beds and imbedded masses in clay-slate and grey-wacke; and in roundish and angular masses in sandstone.

Geographic Situation.—It occurs in different parts of the great tract of clay-slate and grey-wacke, which extends from St. Abb's Head to Port Patrick; also in the Pentland Hills near Edinburgh.

Second Kind.—Lydian-Stone, *Jameson.*—Lidischerstein, *Werner.*

External Characters.—Colour greyish-black, which passes into velvet-black. Occurs massive. Traversed by quartz veins. Internally glimmering. Fracture generally even, and approaches sometimes to flat conchoidal. Opaque.

Geognostic and Geographic Situations.—It occurs in primitive, transition, and secondary rocks in Scotland, England, and other countries.

Use.—This mineral is sometimes used as a touchstone for ascertaining the purity of gold and silver.

Tenth Subspecies.

Flint, *Jameson.*—Feurstein, *Werner.*

External Characters.—Colours grey, yellow, brown, and red. Besides massive, in plates, in angular grains and pieces, it occurs also in globular and elliptical rolled pieces, in the form of sand, and tuberose and perforated. Sometimes occurs in lamellar concretions, which are either straight or concentrically curved. Internally lustre glimmering. Fracture perfect and large, and rather flat conchoidal. Translucent; the blackish varieties are seldom more than translucent on the edges.

Constituent Parts.—Silica,	98.	
Lime,	0.50	
Alumina,	0.25	
Oxide of Iron,	0.25	
Loss,	1.	—100

Vauquelin, Journ. de Mines, n. xxxiii. p. 702.

Geognostic and Geographic Situations.—Occurs in primitive, transition, secondary, and alluvial rocks in most countries of Europe.

Uses.—The principal use of this mineral is for gun-flints, for which purpose it is excellently fitted, on account of its hardness, the abundance of sparks it affords with steel, and the sharp fragments it gives in breaking.

Eleventh Subspecies.

Calcedony, *Jameson.* Kalzedon, *Werner.*

Four kinds, viz. Common Calcedony, Chrysoprase, Plasma, and Carnelian.

First Kind.—Common Calcedony, *Jameson.*—Gemeiner Kalzedon, *Werner.*

External Characters.—Colours grey, yellow, brown, blue, green, and black. Occurs in lamellar, and also in fibrous distinct concretions. Internally dull; the splintery varieties exhibit a faint degree of lustre. Fracture even, which sometimes passes into imperfect conchoidal, and splintery. Generally semi-transparent; but the black and white varieties are only translucent.

Geognostic Situation.—Occurs in primitive, secondary, and alluvial rocks, in balls, kidneys, angular pieces, short and thick beds, veins, and rolled pieces.

Geographic Situation.—It is frequent in most of the trap districts in Scotland, and also in similar tracts on the continents of Europe, Asia, Africa, and America.

Uses.—As it is hard, susceptible of a fine polish, and exhibits beautiful colours, and considerable transparency, it is employed as an article of jewellery.

Second Kind.—Chrysoprase, *Jameson.* Krisopras, *Werner.*

External Characters.—Characteristic colour apple-green, and greenish-grey. Occurs generally massive, and sometimes in plates. Internally dull, seldom glimmering. Fracture even. Translucent, inclining to semi-transparent.

Geognostic and Geographic Situations.—It occurs in plates, and cotemporaneous veins, in primitive serpentine in Silesia.

Uses.—It is considered as a gem, and is cut into ring-stones, necklaces, bracelets, ear-drops, and brooches.

Third Kind.—Plasma, *Jameson.* Plasma, *Werner.*

External Characters.—Colour grass-green. Internally lustre glistening, inclining to glimmering. Fracture imperfect, and rather flat conchoidal. Translucent, inclining to semi-transparent.

Geognostic and Geographic Situations.—It occurs in beds, associated with common calcedony. Most of the specimens in cabinets have been collected among the ruins of Rome.

Use.—It was considered by the Romans as a gem, and was cut into ornaments; and frequently figures were engraved upon it.

Fourth Kind.—Carnelian, *Jameson.* Carneol, *Werner.*

External Characters.—Colours red, brown, yellow, green, and white. Occurs massive, and in fibrous lamellar concretions. Fracture perfect conchoidal, or splintery in the reniform varieties. Lustre glistening, sometimes passing into shining, and vitreous. Generally semi-transparent; seldom translucent.

Geognostic and Geographic Situations.—It frequently occurs as a constituent part of agate, and in general has the same geognostic situation as common calcedony. The secondary trap-rocks, so abundant in Scotland, often contain carnelian, either alone, or in agate. The most beautiful carnelians are brought to this country from Arabia, India, Surinam, Siberia, and Sardinia.

Uses.—It is cut into seal-stones, ring-stones, bracelets, necklaces, brooches, and crosses; and figures are often engraved on it.

Twelfth Subspecies.

Heliotrope, *Jameson.* Heliotrop, *Werner.*

External Characters.—Colour green, with red and yellow spots. Occurs massive. Internal lustre glistening, and resinous. Fracture conchoidal. Generally translucent on the edges; some varieties translucent.

Geognostic and Geographic Situations.—It is found in rocks belonging to the secondary trap-formation, in Siberia, Tartary, Iceland, and even in Scotland.

Uses.—It is cut and polished, and worn as an ornamental stone.

Thirteenth Subspecies.

Jasper.

Five kinds, viz. Egyptian Jasper, Striped Jasper, Porcelain Jasper, Common Jasper, and Agate Jasper.

First Kind.—Egyptian Jasper, *Jameson.*—Brauner Egyptischer Jaspis, *Werner.*

External Characters.—Colours brown, yellow, and grey, frequently disposed in concentric stripes, alternating with black stripes. In the brown colour there sometimes occur black spots, and similar coloured dendritic delineations. Internally partly glistening, partly glimmering. Fracture conchoidal. Very feebly translucent on the edges, or almost opaque.

Geognostic and Geographic Situations.—It occurs loose in the sands of the desert, and in conglomerate rocks in Egypt.

Uses.—It is cut and worn as an ornamental stone.

Second Kind.—Striped Jasper, *Jameson.* Band Jaspis, *Werner.*

External Characters.—Colours grey, green, yellow, and red, and seldom blue. There are always several colours together, and these are arranged in striped and flamed, and sometimes in spotted delineations. Occurs massive. Internally dull. Fracture conchoidal. Opaque, or very feebly translucent on the edges.

Geognostic and Geographic Situations—It occurs in secondary clay-porphyry in the Pentland Hills near Edinburgh; but the most beautiful varieties are found in Siberia.

Use.—This mineral receives an excellent polish, and hence is used like agate for ornamental purposes.

Third Kind—Porcelain-Jasper, *Jameson.* Porzellan Jaspis, *Werner.*

External Characters.—Colours grey, blue, yellow, and seldom black and red. Occurs most commonly massive, and is frequently cracked in all directions. Internally glistening, sometimes approaching to shining, sometimes to glimmering, and even to dull; and the lustre vitreo-resinous. Fracture conchoidal. Opaque.

Geognostic and Geographic Situations.—It occurs along with pseudo-volcanic rocks in Fifeshire; near Dudley in Warwickshire; and in many other parts of Europe and America.

Fourth Kind.—Common Jasper, *Jameson.* Gemeiner Jaspis, *Werner.*

External Characters.—Colours red, brown, and black. Occurs massive. Internally varies from shining to dull; and lustre resinous-vitreous. Fracture of some varieties is more or less perfect and flat conchoidal, and those have a shining or glistening lustre; in others it is even, with a glimmering lustre, or fine earthy and dull. Opaque, or very faintly translucent on the edges.

Geognostic and Geographic Situations.—It occurs in veins and imbedded masses in primitive, transition, and secondary rocks in Scotland, England and Ireland. It is not unfrequent on the continents of Europe, Asia, Africa, and America.

Uses.—When it occurs in sufficiently large masses, it is cut into various ornamental articles, as vases, snuff-boxes, ringstones, &c.

Fifth Kind.—Agate-Jasper, *Jameson.* Agat-Jaspis, *Werner.*

External Characters.—Colours white, yellow, and red. Several colours generally occur together, and these are arranged either in clouded, flamed, or striped delineations; of these the striped are either disposed in a circular manner, or fortification-wise. Occurs massive. Frequently occurs in distinct concretions, which are either fortification-wise bent, or concentric lamellar. Internally dull. Fracture small and flat conchoidal, approaching to even.

Geognostic Situation.—Occurs principally in layers, in agate-balls, in amygdaloid; likewise in agate-balls and veins in porphyry.

Geographic Situation.—Occurs in the agates of the middle district of Scotland, &c.

Fourtneeth Subspecies.

Float-stone, or Spongiform Quartz, *Jameson.*—Schwimmstein, *Werner.* Quartz nectique, *Hauy.*

External Characters.—Colours white and grey. Occurs in porous, massive, and tuberose forms. Internally dull. Fracture coarse earthy. Feebly translucent on the edges. Soft, but its particles are as hard as quartz.

Geognostic and Geographic Situations.—It occurs incrusting flint, or in imbedded masses in a secondary limestone, at St. Ouen, near Paris.

Agate, *Jameson.*

Agate is not, as some mineralogists maintain, a simple mineral, but is composed of various kinds of the quartz family, intimately joined together, and the whole mass is so compact and hard, that it receives a high polish. Agate is principally composed of calcedony, with flint, hornstone, carnelian, jasper, cacholong, amethyst, and quartz. Of these minerals, sometimes only two, in other instances more than three, occur in the same agate; and these are either massive, disseminated, or in layers.

II. Indivisible or Uncleavable Quartz, *Jameson.* Untheilbarer Quartz, *Mohs.*

This species contains eight subspecies, viz. 1. Quartzy Sinter, 2. Hyalite, 3. Opal, 4 Menilite, 5. Obsidian, 6. Pitchstone, 7. Pearlstone, 8. Pumice.

First Subspecies.

Quartzy or Siliceous Sinter, or Pearl Sinter, *Jameson.* Kieselsinter, *Werner.*

This is the siliceous incrustation met with around hot springs in Iceland, and other volcanic countries.

Second Subspecies.

Hyalite, *Jameson.* Hyalith, *Werner.*

External Characters.—Colours white, grey and green. Generally reniform, botryoidal, and sometimes stalactitic, and in crusts. Internally shining and splendent; and lustre vitreous, slightly inclining to resinous. Fracture conchoidal. Translucent, approaching to semitransparent.

Geognostic and Geographic Situations.—It has been hitherto found principally near Frankfort, on the Mayne, where it occurs in fissures in vesicular basalt and basaltic greenstone.

Third Subspecies.

Opal, *Jameson.* Opal, *Werner.*

This subspecies is divided into seven kinds, viz. Precious Opal, Common Opal, Fire Opal, Mother-of-Pearl Opal or Cacholong, Semi-Opal, Jasper-Opal, and Wood-Opal.

First Kind.—Precious Opal, *Jameson.* Edler Opal, *Werner.*

External Characters.—Most common colour milk-white, which at the same time displays a fine play of beautiful colours. Occurs massive, and disseminated. Internally splendent, and vitreous. Fracture conchoidal. Brittle. Uncommonly easily frangible.

Const. Parts.—	Silica,	90
	Water,	10—100

Opal of Czscherwenitza, according to *Klaproth.*

Geognostic and Geographic Situations.—It occurs in small veins in clay-porphyry, generally accompanied with semi-opal; in Hungary, and some other countries.

Uses.—Few gems are more beautiful than the opal. The elegant play of the richest, purest, and most beautiful colours have procured for it a high rank among the precious stones. It is worked into ringstones, necklaces, ear-drops, and other ornaments.

Second Kind.—Common Opal, *Jameson.* Gemeiner Opal, *Werner*

External Characters.—Colours white, grey, yellow, red, and green. Occurs massive, and disseminated. Internally splendent, passing into shining; and vitreous. Fracture conchoidal. Most commonly semi-transparent.

		Of Telkobanya.
Const. Parts.—	Silica,	93.50
	Oxide of iron,	1 0
	Water,	5.0—99.50

Geognostic and Geographic Situations.—It occurs in veins, along with precious opal, in clay-porphyry, in Hungary and other countries.

Third Kind.—Fire Opal, *Jameson.*—Feur Opal, *Karst.*

External Characters.—Principal colour hyacinth-red, which passes through honey-yellow into wine yellow; and upon lighter places shews a carmine-red and apple-green iridescence. In its interior, dendritic delineations are sometimes to be observed. Internally splendent, and lustre vitreous. Occurs in lamellar distinct concretions. Fracture conchoidal. Completely transparent.

Geognostic and Geographic Situations.—It has hitherto been found only in America, at Zimapan in Mexico, where it was first observed by Sonnenschmid and Humbold, imbedded in porphyry.

Fourth Kind.—Mother-of-Pearl Opal, or Cacholong, *Jameson.* Perlmutter Opal, *Karsten.*

External Characters.—Colour milk white, and sometimes dendritic. Occurs massive, and disseminated. Externally dull; internally alternates from dull to glistening and shining, and pearly. Occurs in granular distinct concretions. Fracture flat conchoidal, but becomes earthy on the action of the atmosphere. Opaque.

Geognostic and Geographic Situations.—It occurs, along with calcedony, in trap rocks in the island of Iceland; in the Faroe islands; also in Greenland; and in Bocharia.

Fifth Kind.—Semi-Opal, *Jameson.* Halb-Opal. *Wer.*

External Characters.—Most common colours white, grey, and brown. Occurs not only massive and disseminated, but also tuberose, small reniform, small botryoidal, and stalactitic. Externally glistening; internally, generally glistening. Fracture conchoidal. More or less translucent, and sometimes passes to translucent on the edges.

Geognostic and Geographic Situations. It occurs in porphyry and amygdaloid, in Scotland, Iceland, France, Germany, &c.

Sixth Kind.—Jasper-Opal, or Ferruginous-Opal, *Jameson.* Opal-Jaspis, *Werner.*

External Characters.—Colours red, yellow, and grey. Occurs massive. Internally lustre shining, approaching to splendent, and intermediate between vitreous and resinous. Fracture perfect conchoidal, and sometimes rather flat conchoidal. Opaque, and sometimes feebly translucent on the edges.

Geognostic and Geographic Situations.—It is found in large and small pieces in porphyry, near Telkobanya and Tokay in Hungary, and in other parts of Europe.

Seventh Kind.—Wood-Opal, *Jameson* —Holz-Opal, *Werner.*

External Characters. Occurs most commonly white, grey, or brown, and sometimes also black. Occurs in pieces which have the shape of branches and stems. Internally lustre shining, and sometimes splendent, glistening, or glimmering. Cross fracture conchoidal; the longitudinal fracture sometimes modified by the remaining fibrous woody texture. More or less translucent; sometimes only translucent on the edges.

Geognostic and Geographic Situations.—It is found in alluvial land at Zastravia in Hungary; and is said to occur in secondary trap-rocks in Transylvania.

Uses.—It is cut into plates, and is then used for snuff-boxes, and other ornamental articles.

Fourth Subspecies.

Menilite, *Jameson.*

First Kind.—Brown Menilite, *Jameson.* Brauner Menilite, *Hoffmann.*

External Characters.—Colour chesnut-brown. On the surface sometimes of a bluish colour. Occurs always tuberose. External surface rough and dull; internally faintly glistening, and lustre intermediate between resinous and vitreous. Fracture very flat conchoidal. Translucent on the edges.

Const. Parts.—	Silica,	85.5
	Alumina,	1.0
	Lime,	0.5
	Oxide of Iron,	0.5
	Water, and Carbonaceous Matter,	11.0
	Klaproth, Beit. b. ii. s. 169.	98.5

Geognostic and Geographic Situations.—It has hitherto been found only at Menil Montant, near Paris, where it occurs imbedded in adhesive-slate, in the same manner as flint is in chalk.

Fifth Subspecies.

Obsidian, *Jameson.* Obsidian, *Werner.*

This subspecies is divided into two kinds, viz. Translucent Obsidian. Transparent Obsidian.

First Kind.—Translucent Obsidian, *Jameson.*—Durchscheinender Obsidian, *Hoffmann.*

External Characters.—Colours black, grey, and green. Occurs massive. Internally splendent, seldom shining, and lustre vitreous. Fracture conchoidal. Alternates from translucent to translucent on the edges. Very brittle. Easily frangible. Streak grey.

Chemical Characters.—The black obsidian of Iceland, according to Da Camara, on charcoal, before the blowpipe, melts into a pale ash-grey, imperfect, vesicular glass.

		American.
Const. Parts.—	Silica,	72.0
	Alumina,	12.5
	Natron and Potash,	10.0
	Lime,	0.0
	Oxide of Iron and Manganese,	2.0
	Collet Descotils.	96.5

Geognostic Situation.—This mineral occurs in beds, and imbedded masses and veins, in porphyry, and in various secondary trap rocks.

Geographic Situation.—It occurs in various parts of Europe, Asia, Africa, and America.

Uses.—It is cut into ornamental articles of different kinds.

Second Kind.—Transparent Obsidian, *Jameson.*—Durchsichtiger Obsidian, *Hoffmann.*

External Characters.—Colours blue, brown, and white. Internally splendent and vitreous. Fracture conchoidal. Perfectly transparent.

Geognostic and Geographic Situations.—It occurs imbedded in pearlstone-porphyry, at Marekan in Siberia.

Sixth Subspecies.

Pitchstone. *Jameson.*—Pechstein, *Werner.*

External Characters.—Colours green, grey, blue, yellow, brown, and black. Occurs massive. Internally shining, and glistening; lustre vitreo-resinous. Feebly translucent on the edges. Fracture conchoidal, coarse-grained uneven, and coarse splintery.

Constit. Parts.—Silica, 73; Alumina, 14.50; Lime, 1.0; Oxide of iron, 1.00; Oxide of manganese, 0.10; Natron, 1.75; Water, 8.50=99.85. *Klaproth.*

Geognostic and Geographic Situations.—It occurs in primitive, transition, and secondary rocks, in Scotland, Ireland, Saxony, &c.

Seventh Subspecies.

Pearl-Stone, *Jameson.* Perlstein, *Werner.*

External Characters.—Colours grey, black, and red. Occurs massive, disseminated; also in roundish granular and curved lamellar concretions. Lustre shining and pearly. Translucent on the edges, or translucent. Very easily frangible.

Constit. Parts.—Silica, 77.; Alumina, 13.0; Oxide of iron and manganese, 2.0; Potash, 2.0; Lime, 1.5; Natron, 0.7; Water, 4=100.2, *Vauquelin.*

Geognostic and Geographic Situations.—It occurs in porphyry, in Hungary, Spain, North of Ireland, Iceland, and Mexico.

Eighth Subspecies.

Pumice, *Jameson.* Bimstein, *Werner.*

External Characters.—Colours white and grey. Occurs vesicular; vesicles much elongated, and contain capillary fibres. Internally glistening or glimmering, and pearly. Principal fracture curved and parallel fibrous; cross fracture uneven. More or less translucent on the edges. Very brittle, and easily frangible.

Constit. Parts.—Silica, 77.50; Alumina, 17.50; Natron and Potash, 3.00; Iron with Manganese, 1.75,= 99.75, *Klaproth.*

Geognostic and Geographic Situations.—Occurs along with various porphyries and obsidians, in the Lipari islands, and other quarters.

Uses.—Is used for polishing glass and soft stones; also by parchment-makers, curriers, and hat-makers, and hence forms a considerable article of trade, and is exported from the Lipari islands in great quantities to the different countries of Europe.

Observations.—Obsidian, pitchstone, pearlstone, and pumice, ought to form a separate group in the species of the Genus Quartz.

Genus VIII. AXINITE, *Jameson.*

Prismatic. Perfect vitreous lustre. Hardness=6.5—7.0. Specific gravity=3.0—3.3.

1. Prismatic Axinite. *Jameson.*—Prismatischer Axinit, *Mohs.*—Thumerstein, *Werner.*

Pyramid unknown. Cleavage prismatic=101°. 30′.

External Characters.—Colours clove-brown, plumb-blue, grey, and black. Seldom massive, most frequently crystallized in very oblique four-sided prisms. Massive varieties occur in curved lamellar distinct concretions. Externally, lustre splendent; internally, alternates from glistening to shining, and is vitreous, slightly inclining to resinous. Fracture fine-grained, uneven, or conchoidal. Alternates from perfectly transparent to feebly translucent.

Chemical Characters.—Easily fusible with ebullition into a bottle-green glass, which by continuance of the heat becomes nearly black.

Constit. Parts.—	Silica,	50.50
	Alumina,	16.
	Lime,	17.
	Oxide of Iron,	9.50
	—— of Manganese,	5.25
	Potash,	0.25—98.50
		Klaproth, t. v. p. 28.

Geognostic Situation.—Occurs in primitive mountains, in rocks of gneiss, mica-slate, clay-slate, and hornblende-rock, and is found in Cornwall, and in various districts on the continent of Europe.

Genus IX. CHRYSOLITE.

Prismatic vitreous lustre. Hardness=6.5—7.0. Sp. gr.=3.3—3.5.

1. Prismatic Chrysolite, *Jameson.*—Prismatischer Krisolith, *Mohs.*—Peridot, *Hauy.*

Prism=131° 48′. Cleavage perfect, in the direction of the shorter diagonal, and less so in direction of the longer diagonal.

Two subspecies, viz. Chrysolite and Olivine.

First Subspecies.

Chrysolite, *Jameson.*—Krisolith, *Werner.*

External Characters.—Colour green. Occurs in angular pieces, roundish pieces, and often crystallized in four and six-sided prisms, variously acuminated, and bevelled, and truncated on the lateral edges. Internally, lustre splendent and vitreous. Fracture conchoidal. Transparent, and refracts double.

Constit. Parts.—	Silica,	39.00
	Magnesia,	43.50
	Iron,	19.00—101.50
		Klaproth Beit. b. i. s. 110.

Geognostic and Geographic Situations.—Is found in alluvial soil in Upper Egypt, and on shores of the Red Sea.

Uses.—It is cut and polished, and made into necklaces, hair ornaments, and ring-stones.

Second Subspecies.

Olivine, *Jameson.*—Olivin, *Werner.*

External Characters.—Colours olive-green and yellow. Occurs massive, in grains, and in roundish pieces.—When crystallized, which is rarely the case, it is in the form of rectangular four-sided prisms, which are always imbedded. Massive varieties occur in small and angulo-granular concretions. Internally, lustre shining and glistening, and vitreo-resinous. Fracture small-grained uneven, sometimes passing into imperfect small conchoidal. Translucent, passing into semi-transparent, seldom transparent.

Geognostic and Geographic Situations.—It occurs imbedded in basalt, greenstone, porphyry and lava, generally accompanied with augite, in Scotland, Germany, Italy, and other countries.

Genus X. TOURMALINE.

One axis. Rhomboidal. Hardness=7.0—7.5. Sp. gr.=3.0—3.2.

This genus contains one species, viz. Rhomboidal Tourmaline.

I. Rhomboidal Tourmaline.—Rhomboedrischer Turmalin, *Mohs.*

Rhomboidal. Rhomboid=133° 26′. Cleavage rhomboidal, and in direction of sides of a six-sided prism.

It is divided into two subspecies, viz. Tourmaline and Schorl.

First Subspecies.

Tourmaline, *Jameson.*—Turmalin, *Werner.*

External Characters.—Its principal colours are green, brown, red, blue, yellow, and white. Occurs very seldom massive, or in prismatic concretions; scarcely ever disseminated; oftener in rolled pieces; but most frequently crystallized in three, four, six, and nine-sided prisms, variously accuminated. The lateral planes are generally cylindrical convex, and deeply longitudinally streaked; the acuminating planes are mostly smooth and shining; sometimes the planes on one extremity are smooth, but on the other rough. Internally, lustre splendent and vitreous. Fracture nearly perfect, and small conchoidal. Alternates from nearly opaque to completely transparent. Refracts double in a middling degree. When viewed perpendicular to the axis of the crystal, it is more or less transparent, but in the direction of the axis, even when the length of the prism is less than the thickness, it is opaque.

Physical Characters.—By friction, it exhibits signs of vitreous electricity; by heating, vitreous electricity at one extremity, and resinous electricity at the other.

Chemical Characters.—Before the blowpipe it melts into a greyish-white vesicular enamel; but the red-coloured Siberian tourmaline is infusible.

		Green Tourmaline from Brasil.
Constituent Parts.—	Silica,	40.
	Alumina,	39.
	Lime,	3.84
	Oxide of Iron,	12 5
	Oxide of Manganese,	2.
	Loss,	2.66—100

Vauquelin, Ann. de Chim. N. 88. p. 105.

Geognostic and Geographic Situations.—Tourmaline occurs in primitive rocks in Scotland, England, Germany, Norway, Italy, and many other countries.

Uses.—The green, blue, and brown varieties are sometimes cut and polished, and worn as ornamental stones.

Second Subspecies.

Common Schorl, *Jameson.*—Gemeiner Schorl, *Werner.*

External Characters.—Colour velvet-black, of various degrees of intensity. Occurs massive, disseminated, and frequently crystallized, in three, six, and nine-sided prisms, that present various acuminations, truncations, and bevelments. Occurs in granular and prismatic concretions. Internally its lustre is intermediate between shining and glistening, and is vitreous. Fracture intermediate between conchoidal and uneven. Opaque. Affords a grey streak.

		Common Schorl from Eibenstock.
Constituent Parts.—	Silica,	36.75
	Alumina,	34.50
	Magnesia,	0.25
	Oxide of Iron,	21.0
	Potash,	6.0 —98.50

Klaproth, Beitrage, b. 5. s. 148, 149.

Physical Characters.—Exhibits the same electrical properties as tourmaline.

Geognostic and Geographic Situations.—Occurs in primitive mountains in most extensive alpine districts in Europe; and also in Asia, Africa, and America.

Genus XI.—GARNET.

Tessular, pyramidal, prismatic. If red, the Sp. gr. =3.7. and more. If black, sp. gr.=3.9 and less. No pure vitreous lustre. If prismatoidal, the hardness is= 7 and more, and no pure vitreous lustre. Hardness ranges from 6 5 to 7.5. If 7.5, it is red or brown. Sp. gravity=3.3—4.3.

1. Pyramidal Garnet or Vesuvian, *Jameson.*—Pyramidaler Granat, *Mohs.*—Vesuvian, *Werner.*—Idocrase, *Hauy.*

Pyramidal. Pyramid=129° 30′, 74° 14′. Cleavage in the direction of the lateral planes of the prism; in the direction of the diagonals of the prism; and also in the direction of the terminal planes of the prism. Hardness =6.5. Sp. gravity=3 3—3 4.

External Characters.—Colours green and brown. Occurs massive, disseminated, and in granular concretions; but more frequently crystallized, in rectangular four-sided prisms, variously acuminated, truncated, and bevelled. Lateral planes of the prisms are longitudinally streaked; but the truncating and terminal planes are smooth. Externally the crystals are splendent; internally glistening, approaching to shining, and the lustre is vitreo-resinous. Fracture is small-grained uneven. Alternates from translucent to translucent on the edges, and refracts double.

Chemical Characters.—Before the blow-pipe it melts without addition into a yellowish and faintly translucent glass.

		Vesuvian of Vesuvius.
Constit. Parts.—	Silica,	35 5
	Lime,	33.0
	Alumina,	22.25
	Oxide of Iron,	7.5
	Oxide of Manganese,	0.25
	Loss,	1.5—100

Klaproth, *Beit.* b. ii. s. 32. & 38.

Geognostic and Geographic Situations.—Occurs in various primitive rocks, in Ireland, Italy, Norway, Switzerland, &c.

Uses.—At Naples it is cut into ring-stones, and is sold under various names: the green-coloured varieties are denominated Volcanic Chrysolite; and the brown, Volcanic Hyacinth.

Obervation.—The *Egeran* of Werner is a variety of this species.

2. Dodecahedral Garnet, *Jameson.*

Tessular. Cleavage dodecahedral. Hardness=6.5—7.5. Sp. gravity=3.5—4.3.

This species contains nine subspecies, viz. 1. Pyreneite; 2. Grossulare; 3. Melanite; 4. Pyrope; 5. Garnet; 6. Allochroite; 7. Colophonite; 8. Cinnamon-stone; 9. Helvin.

First Subspecies.

Pyreneite, *Jameson.*—Pyreneit, *Werner.*

External Characters.—Colour greyish-black. Occurs massive, and crystallized in the form of rhomboidal dodecahedrons. Externally glistening, inclining to shining, and metallic-like. Internally glistening and vitreous. Fracture small-grained uneven. Opaque.

Geognostic and Geographic Situations.—Occurs in primitive limestone in the Pic of Eres-Lids, near Bareges, in the French Pyrenees.

Second Subspecies.

Grossulare, *Jameson.*—Grossular, *Werner.*

External Characters.—Colour asparagus-green. Crystallized in acute double eight-sided pyramids, flatly acuminated on both extremities by four planes; the acuminating planes set on the alternate edges of the double eight-sided pyramid. Planes of the crystals are smooth.

Externally shining; internally shining, and lustre resinous. Fracture intermediate between conchoidal and uneven. Translucent.

Geognostic and Geographic Situations.—Occurs imbedded in small crystals, along with vesuvian, in a pale greenish-grey claystone, near the river Wilui in Siberia; also in the Bannat of Temeswar.

Third Subspecies.

Melanite. *Jameson.*—Melanit, *Werner.*

External Characters —Colour velvet-black. Generally crystallized in rhomboidal dodecahedrons, truncated on the edges. Internally shining, inclining to glistening, and resino-vitreous. Fracture conchoidal. Opaque.

Geognostic and Geographic Situations.—Occurs in primitive and secondary rocks in Italy, Germany, and Norway.

Fourth Subspecies.

Pyrope, *Jameson.*—Pyrope, *Werner.*

External Characters.—Colour dark blood-red. Occurs in roundish and angular grains. Lustre splendent, and vitreo-resinous. Fracture conchoidal. Is transparent, and refracts double.

Geognostic and Geographic Situation.—It occurs in serpentine and trap, in Bohemia.

Use.—This beautiful gem is employed in almost every kind of jewellery, and is generally set with a gold foil.

Fifth Subspecies.

Garnet, *Jameson.*

This subspecies is divided into two kinds, viz. Precious Garnet and Common Garnet.

First Kind.—Precious Garnet, *Jameson.*—Edler Granat, *Werner.*

External Characters.—All the colours of this gem are dark-red, which generally fall into blue. Occurs in roundish grains, and crystallized in rhomboidal dodecahedrons, and in the form of the leucite. Internally it is shining, bordering on splendent; and vitreous, inclining slightly to resinous. Fracture conchoidal. Sometimes occurs in lamellar distinct concretions. Alternates from completely transparent to translucent.

Constit. Parts.—Silica,	.	39 66
Alumina,	.	19 66
Black oxide of Iron,		39.68
Oxide of Manganese,		1 80—100.80

Berzelius, in Afhandlinger, vol. iv. p. 385.

Chemical Character.—Before the blowpipe it melts pretty easily into a black scoria or enamel.

Geognostic and Geographic Situations.—Occurs imbedded in primitive rocks, in Scotland, England, Ireland, Germany, Norway, Sweden, and many other countries.

Use.—This beautiful gem is not so highly valued at present as it was a century ago. The larger kinds are used as ring stones, and, after cutting and polishing, are set either *au jour*, or are provided with a silver or violet-blue foil.

Second Kind —Common Garnet, *Jameson.*—Gemeiner Granat, *Werner.*

External Characters.—Brown and green are its most common colours. Occurs most commonly massive: sometimes crystallized, and possesses all the figures of the precious garnet. Occurs in angulo-granular distinct concretions. Lustre shining, or glistening, very rarely splendent. Internally lustre glistening, seldom shining, and intermediate between resinous and vitreous. Fracture fine-grained uneven, sometimes slightly inclining to imperfect conchoidal, or to splintery.

Geognostic and Geographic Situations.—It occurs massive or crystallized in primitive rocks in Scotland, England, Ireland, Norway, Sweden, Germany, Italy, and many other countries.

Use.—On account of its easy fusibility and richness in iron, it is frequently employed as a flux in smelting rich iron-ores, and as an addition to poor ores.

Sixth Subspecies.

Allochroite, *Jameson.*—Allochroit, *Werner.*

External Characters.—Colours grey, brown, and green. Occurs massive. Internally glimmering, rarely glistening, and lustre resinous. Fracture uneven, sometimes even passing to conchoidal. Feebly translucent on the edges.

Geognostic and Geographic Situations.—It has hitherto been found only in Viuls iron-mine near Drammen in Norway, where it is associated with calcareous spar, reddish-brown garnet, and magnetic iron-ore.

Seventh Subspecies.

Colophonite, or Resinous Garnet, *Jameson.*

External Characters.—Colours brown, red, and green. Occurs massive, in angulo-granular concretions; and crystallized in rhomboidal dodecahedrons, either perfect, or truncated on the edges. Appears as if melted. Internally shining; externally splendent. Lustre resino-adamantine. Fracture imperfect conchoidal. Translucent, or only translucent on the edges.

Geognostic and Geographic Situations.—It occurs in beds of magnetic iron-ore, which are subordinate to gneiss, at Arendal in Norway; and in talc-slate at Salvagnengo in Piedmont. It is also found in the Island of Ceylon.

Eighth Subspecies.

Cinnamon Stone, *Jameson.*—Kanelstein, *Werner.*—Essonite, *Hauy.*

External Characters.—Principal colour intermediate between hyacinth-red and orange-yellow. Occurs massive, and in granular distinct concretions. Internally shining, approaching to glistening; and lustre resino-vitreous. An indistinct cleavage sometimes visible, indicating an oblique prism of 102° 40′. Fracture in every direction rather imperfect, and flat conchoidal. Transparent and semi-transparent; generally so impure and full of cracks, that faultless specimens rarely occur. Refracts single. Hardness 7, 7.5. Sp. gr. 3.5, 3.7.

Geognostic and Geographic Situation.—It is found in alluvial deposites, and associated with quartz, tabular spar, and iron-ore, in gneiss, in the island of Ceylon.

Use.—It is cut as a precious-stone, and, when free of flaws, is of considerable value.

Observation.—Appears to be a distinct species.

NINTH SUBSPECIES.

HELVINE, *Jameson*.—Helvin, *Werner*.

External Characters.—Colour wax-yellow. Occurs disseminated, and crystallized in tetrahedrons, which are perfect or truncated on the angles. Internally glimmering or shining. Externally vitreous; internally it inclines to resinous. Fracture small-grained uneven. Crystals strongly translucent.

Geognostic and Geographic Situation.—It occurs in gneiss, near Schwarzenberg in Saxony.

Observation.—Probably a distinct species.

3. PRISMATIC GARNET or GRENATITE, *Jameson*.—Prismatischer Granat, *Mohs*. Granatit, *Werner*. Staurotide, *Hauy*.

Prismatic. Prism=129° 30′. Cleavage prismatoidal, in the direction of the shorter diagonal of the prism. Hardness=7.0, 7.5. Sp. gr=3.3, 3.9.

External Characters.—Colour dark reddish-brown. Occurs only crystallized, and in the form of oblique four-sided prisms, sometimes truncated on the lateral edges. Internally the cleavage is shining and splendent; fracture glistening and glimmering, with a resino-vitreous lustre. Fracture small-grained uneven, which sometimes approaches to small conchoidal. Often opaque, sometimes translucent, and very rarely semi-transparent.

		St. Gothard.
Const. Parts.—	Alumina, . .	41.
	Silica, . .	37.5
	Oxide of Iron, .	18.25
	Oxide of Manganese,	0.5
	Loss, . .	2.75—100

Klap. Bullet des Scien. de la Soc. Phil. t. i. p. 171.

Geognostic and Geographic Situations.—The geognostic relations of this mineral are nearly the same with those of precious garnet. It occurs in Aberdeenshire, the Shetland Islands, county of Wicklow in Ireland, &c.

GENUS XII.—ZIRCON.

Pyramidal. Hardness=7.5. Sp. gr.=4.5, 4.7.

PYRAMIDAL ZIRCON, *Jameson*.—Pyramidaler, Zircon, *Mohs*.

Pyramidal. Pyramid=123° 19′; 84° 20′. Cleavage pyramidal, or in the direction of the lateral planes of the oblique prism.

This species is divided into two subspecies, Common Zircon, and Hyacinth.

FIRST SUBSPECIES.

COMMON ZIRCON, *Jameson*.—Zirkon, *Werner*.

External Characters.—Colour grey, also white, green, and brown; and rarely yellow, blue, and red. Occurs crystallized in rectangular four-sided prisms, acuminated with four or eight planes. Internally splendent, passing into shining, and lustre intermediate between adamantine and resinous. Fracture perfect and flat conchoidal. Alternates from transparent to opaque. Refracts double in a high degree.

Chemical Character.—It is infusible, without addition, before the blowpipe.

		Zircon of Ceylon.
Const. Parts.—	Zirconia, . .	69.00
	Silica, . .	26.50
	Oxide of Iron, .	0.50—96.00

Klaproth, Beit. i. s. 222.

SECOND SUBSPECIES.

HYACINTH, *Jameson*.—Hiacinth, *Werner*.

External Characters.—Colours red, brown, yellow, grey, green, and white. Occurs crystallized, in rectangular four-sided prisms acuminated with four planes, set on the lateral edges. Internally specular splendent, and lustre intermediate between resinous and vitreous. Fracture perfect and small conchoidal. Alternates from transparent to semi-transparent. Refracts double.

Geognostic and Geographic Situations of the Zircon species, including Common Zircon and Hyacinth.—It occurs in grains and crystals, imbedded in gneiss and syenite; also imbedded in basalt and lava, and dispersed through alluvial soil, in Shetland Islands, Sutherlandshire, Inverness-shire, Galloway, &c. The finest specimens are brought from the East, principally from Ceylon.

GENUS XIII.—GADOLINITE.

Three axes. Prismatic. Black. Streak greenish grey. Hardness=6.5—7.0. Sp. gr. 4.0—4.3.

This genus contains but one species, viz. Prismatic Gadolinite.

I. PRISMATIC GADOLINITE, *Jameson*.—Prismatischer Gadolonit, *Mohs*.—Gadolinit, *Karsten*.

Prism 100 nearly.

External Characters.—Colours velvet-black; very rarely hyacinth-red. Occurs massive and disseminated; the massive varieties sometimes composed of granular or prismatic concretions, the surfaces of which have frequently a whitish or bluish aspect, and vary from glistening to dull. It very rarely occurs crystallized in six-sided prisms. Internally shining; lustre resinous, inclining to vitreous. Fracture generally conchoidal; seldom uneven.

Constituent Parts.—Silica, 25,80; Yttria, 45.0; Oxide of Cerium, 16.69; Oxide of iron, 10.26; Volatile matter, 0.60. =98.35. *Berzelius*.

Geognostic and Geographic Situations.—Occurs in beds of felspar in mica-slate, at Ytterby near Waxholm in Roslagen, and in granite at Finbo near Fahlun, in Sweden.

ORDER VIII.—ORE.

If metallic, the colour is dark. If not metallic, lustre adamantine, or imperfect metallic. If the streak is yellow or red, the hardness =3.5 and more. If the specific gravity =4 8 and more, and the streak brown, or black, the hardness =5. and more, or very perfectly prismatoidal. Hardness =2.5.—7. If 4.5 and less, the streak is red, yellow, or black. If 6.5 and more, and white streak, the specific gravity=6.5 and more. Sp. gr. =3.4.—7.4.

GENUS I.—TITANIUM ORE.

Pyramidal, prismatic. Hardness =5.0,—6.5. Sp. gr. =3.4,—44. If less than 4.2, the streak is white.

I. Prismatic Titanium Ore, or Sphene, *Jameson*.—Prismatisches Titan-erz, *Mohs*.

Vertical prism =136° 50′. Horizontal prism in the direction of one of the diagonals, =120°. Streak white. Hardness =5.0.—5.5. Sp. gr. =3.4,—3.6.

This species is divided into two subspecies, viz. Common Sphene, and Foliated Sphene.

First Subspecies.

Common Sphene, *Jameson*.—Braun Manakerz, *Werner*. Titane Siliceo Calcaire, *Hauy*.

External Characters.—Colours brown, green, grey, and white. Occurs in granular distinct concretions, and crystallized in oblique four-sided prisms, variously modified by bevelments, truncations, and acuminations. Internally shining or glistening; lustre adamantine, sometimes inclining to resinous, sometimes to vitreous. Fracture imperfect conchoidal, which inclines to uneven. Alternates from opaque to translucent.

		St. Gothard.
Constituent Parts.—	Oxide of Titanium	33.3
	Silica, . .	28.0
	Lime, . .	32.2
	Water, . .	0—93.5

Cordier in Jour. des Mines, N. 73, 70.

Geognostic and Geographic Situations.—It occurs in small and very small crystals, imbedded in the syenite of the Criffle and other hills in Galloway; in the syenite of Inverary; and in various other quarters in Scotland.

Second Subspecies.

Foliated Sphene. *Jameson*.—Gelb Manakerz, *Werner*. Titane siliceo-calcaire, *Hauy*.

External Characters.—Occurs yellow, brown, and grey. Occurs massive, in straight lamellar concretions, and crystallized in the same figures as the preceding subspecies. Lustre on the cleavage splendent or shining; on the imperfect conchoidal and uneven fractures only shining or glistening, and resinous. Fracture imperfect conchoidal, inclining to uneven. Translucent, or only translucent on the edges.

Geognostic and Geographic Situations.—Occurs in primitive rocks in Italy, Bohemia, Norway, and other countries.

II. Prismato Pyramidal Titanium-Ore *Jameson*.—Prismato-Pyramidales Titan-erz. *Mohs*.

Pyramidal. Pyramid =117° 2′; 84° 48′. Most distinct cleavage in the direction of the lateral planes of the rectangular four-sided prism; and another less distinct, parallel with the diagonals of the prism. Streak brown. Hardness =6.0—6.5. Sp. gr. =4.2—4.4.

This species is divided into three subspecies, viz. Rutile, Iserine, and Menachanite.

First Subspecies.

Rutile, *Jameson*.—Rutil, *Werner*. Titane Oxide, *Hauy*.

External Characters.—Colours brown, red, and yellow. Occurs massive, disseminated, in membranes, and in four and six-sided prisms. Internally the lustre is intermediate between adamantine and semi-metallic, and is splendent on the surface of the cleavage, but only shining or glistening in the conchoidal or uneven fractures. Fracture uneven and conchoidal. Streak brown. Transparent or only translucent on the edges.

Geognostic and Geographic Situations.—It is found imbedded, in veins and in drusy cavities, in granite, syenite, gneiss, mica-slate, limestone, chlorite-slate, and hornblende slate, in Scotland, England, and in various countries on the continents of Europe, Asia, and America.

Second Subspecies.

Iserine, *Jameson*.—Iserin, *Werner*.

External Characters.—Colour iron-black, inclining to brownish-black. Occurs in rolled pieces. Internally it alternates from splendent to glistening, and the lustre is metallic. Fracture more or less perfect conchoidal. It is completely opaque.

Constituent Parts.—	Oxide of Titanium,	28
	Oxide of Iron .	72—100

Klaproth, Beit. b. v. s. 206.

Geognostic and Geographic Situations.—In sand of the river Iser.

Third Subspecies.

Menachanite, *Jameson*.—Menacan, *Werner*.

External Characters.—Colour greyish black, inclining to iron black. Occurs only in very small flattish angular grains, which have a rough glimmering surface. Internally it is glistening or glimmering, or the lustre is adamantine, passing into semi-metallic. Opaque.

Geognostic and Geographic Situations.—It is found, accompanied with fine quartz-sand, in the bed of a rivulet which enters the valley of Manaccan in Cornwall.

III. Pyramidal Titanium-Ore, or Octahedrite, *Jameson*.—Pyramidales Titan-erz, *Mohs*. Octaedrit, *Werner*.

Pyramid =97° 38′; 137° 10′. The least perfect cleavage in the direction of the faces of the pyramid; and the most perfect is parallel to the common base of the pyramids. Streak white. Hardness =5.5—6.0. Sp. gr. =3.8—3.9.

External Characters.—Colours blue and brown. Occurs crystallized in double four-sided pyramids. Internally splendent, and lustre adamantine, inclining to semi-metallic. Is strongly translucent or transparent.

Geognostic and Geographic Situations.—It is found at Bourg d'Oisans in Dauphiny, in primitive rocks, and in transition clay-slate in Norway.

Genus II. RED COPPER ORE.

Tessular. Hardness =3.5,—4. Sp. gr. =5.6,—6.0.

This genus contains but one species, viz. Octahedral Red Copper-Ore.

1. Octahedral Red Copper-Ore.—*Jameson*. Octaedrisches Kupfer-erz. *Mohs*.

Tessular. Cleavage octahedral. Streak red.

This species is divided into four subspecies, viz. Foliated Red Copper-ore, Compact Red Copper-ore, Capillary Red Copper-ore, and Tile-ore.

First Subspecies.

Foliated Red Copper-Ore, *Jameson*.—Blättriches Rothkupfererz, *Werner*.

External Characters.—Colour red. Occurs massive, disseminated, in membranes, corroded; also in granular concretions, and crystallized in variously modified octahedrons. Internally alternates from shining to glistening; lustre adamantine, inclining to semi-metallic. Fracture coarse and small-grained uneven. Ranges from opaque to translucent.

Second Subspecies.

Compact Red Copper-Ore, *Jameson.*—Dichtes Rothkupfererz, *Werner.*

External Characters.—Colour red. Occurs massive, disseminated, and in a kind of reniform shape. Internally glimmering, inclining to glistening; lustre semimetallic. Fracture even, inclining to flat conchoidal. Opaque.

Third Subspecies.

Capillary Red Copper-Ore, *Jameson.*—Haarformiges Roth Kupfererz, *Werner.*

External Characters.—Colour red. Occurs in small capillary crystals, also in thin tables, which are sometimes aggregated into amorphous and scopiform flakes. Shining. Lustre adamantine. Translucent.

			Cornwall.
Constituent Parts.	Copper	.	88.5
	Oxygen,	.	11.5——100.0

Chenevix, Phil. Trans.

Geographic and Geognostic Situations.—It occurs in veins in primitive transition and secondary rocks, as Cornwall, and in several mines on the continents of Europe, Asia, and America.

Fourth Subspecies.

Tile-Ore, *Jameson.*—Ziegelerz, *Werner.*

This subspecies is divided into two kinds, viz. Earthy Tile-ore, and Indurated Tile-ore.

First Kind. Earthy Tile-Ore, *Jameson.*—Erdiches Ziegelerz, *Werner.*

External Characters.—Colours red and brown. Occurs massive, disseminated, and incrusting copper-pyrites. Composed of dull dusty particles, which are more or less cohering. Soils slightly. Feels meagre.

Geognostic and Geographic Situations.—Occurs in veins in the Hartz, Tyrol, &c.

Second Kind.—Indurated Tile-Ore, *Jameson.*—Festes Ziegelerz, *Werner.*

External Characters.—Colours red, brown, grey, and black. Occurs massive, disseminated; also in curved lamellar and fibrous concretions. Internally glimmering or glistening, and resinous. Fracture conchoidal.

Constituent Parts.—Werner considers it to be an intimate combination of red copper-ore and brown ironochre. It contains from ten to 50 per cent. of copper.

Geognostic and Geographic Situations.—Occurs in veins in Cornwall and other countries.

Genus III. TIN-ORE.

Zinnerz, *Mohs.*

Pyramidal. Streak not black. Hardness =6.0—7.0. Sp. gr. =6.3—7.0.

This genus contains one species, viz. Pyramidal Tin-Ore.

1. Pyramidal Tin-Ore, *Jameson.*—Pyramidales Zinnerz, *Mohs.*

Pyramidal. Pyramid =133° 36′, 67° 42′. The most perfect cleavage is in the direction of the lateral planes of a rectangular four-sided prism, and another, less perfect, in the direction of the diagonals of the same prism Streak white and brown.

This species is divided into two subspecies, viz. Common Tin-Ore or Tinstone, and Cornish Tin-Ore.

First Subspecies.

Common Tin-Ore or Tintstone, *Jameson.*—Zinstein, *Werner.*

External Characters.—Colours brown, black, green, white, yellow, and red. Occurs most frequently crystallized, and in the form of rectangular prisms, variously modified by truncations and acuminations. Internally alternates from splendent to glistening. Lustre intermediate between resinous and adamantine. Fracture uneven, inclining to conchoidal. Alternates from semitransparent to opaque. Yields a greyish-white streak.

			From Alternon.
Constituent Parts.	Tin,	.	77.50
	Iron,	.	0.25
	Oxygen,	.	21.50
	Silica,	.	0.75——100

Klaproth, Beit. b. ii. s. 256.

Geognostic and Geographic Situations.—Occurs disseminated, in granite, gneiss, mica-slate, clay-slate, porphyry, and in an alluvial form, in what are in Cornwall named *Stream Works.* Cornwall contains the greatest European tin mines, and Banca in India the most extensive beyond Europe.

Second Subspecies.

Cornish Tin-Ore, or Wood-Tin, *Jameson.*—Kornisch Zinnerz, *Werner.*

External Characters.—Colour hair brown, woodbrown, and reddish-brown. Occurs reniform, botryoidal, and globular; and in fibrous distinct concretions. Internally feebly glistening or glimmering, and lustre resinous. Opaque. Streak grey, inclining to brown.

Geognostic and Geographic Situations.—It occurs loose, and in small quantities, along with stream tin, in alluvial deposites (stream-works) in Cornwall.

Genus IV. WOLFRAM ORE.

Scheel-erz, *Mohs.*

Prismatic. Hardness =5.0—5.5. Sp. gr. =7.1.—7.4.

This genus contains one species, viz. Prismatic Wolfram.

1. Prismatic Wolfram, *Jameson.*—Prismatisches Scheel-erz, *Mohs.*—Wolfram, *Werner.*

Prism =120°. Cleavages in the direction of the diagonals of the oblique four-sided prism. Streak dark reddish brown.

External Characters.—Colour black, and rarely a temper-steel tarnish. Occurs massive, and crystallized in oblique four-sided prisms, variously modified by truncation, bevelment, and acumination. Cleavage shining or splendent; fracture glistening; lustre resinous, inclining to adamantine. Fracture coarse and small grained uneven. Opaque.

Constituent Parts.—	Tungstic Acid		67.00
	Oxide of Manganese,		6.25
	Oxide of Iron,		18.10
	Silica,	. .	1.50—92.75

Vauquelin, in Journ. d. Min. N. 19. 18.

Geognostic and Geographic Situations.—Occurs in primitive rocks, in the island of Rona, one of the Hebrides, also in Cornwall and other counties.

Genus V. TANTALUM-ORE.

Tantal-Erz, *Mohs.*

Prismatic. Streak brownish black. Hardness = 6. Sp. gr. =6, 6.3.

This genus contains one species, viz. Prismatic Tantalum-ore.

1. Prismatic Tantalum-Ore.—Prismatisches Tantal-erz, *Mohs.*

Prismatic. Prism unknown.

External Characters.—Colours greyish and brownish black. Occurs massive, disseminated, and crystallized in oblique four-sided prisms, the dimensions of which are unknown. Externally and internally shining or glistening, and lustre resinous, inclining to semi-metallic adamantine. Fracture uneven, or conchoidal. Opaque.

		Finland.
Constituent Parts.—	Oxide of Tantalum,	83
	Oxide of Iron, .	12
	Oxide of Manganese,	8—103

Vauquelin, in Hauy, Tabl. p. 308.

Geognostic and Geographic Situations.—It occurs disseminated in a coarse red granite, at Brokärns.

Genus VI. URANIUM-ORE.

Uran-Erz, *Mohs.*

Form unknown. Streak black. Hardness = 5.5. Sp. gr. = 6.4,—6.6.

This genus contains one Species, viz. Indivisible Uranium-Ore.

1. Indivisible or Uncleavable Uranium-Ore, *Jameson.*—Untheilbares Uran-Erz, *Mohs.*—Uranpecherz, *Werner.*

Uncleavable. Reniform. Massive.

External Characters.—Colour black. Generally occurs massive, seldom disseminated, sometimes reniform; also in granular, lamellar, and prismatic concretions. Internally shining, lustre resinous, inclining to semi-metallic. Fracture conchoidal, which passes into coarse-grained uneven. Opaque.

		Joachimsthal.
Constit. Parts.—	Oxide of Uranium,	86.5
	Black Oxide of Iron,	2.5
	Galena or Lead-glance,	6.0
	Silica, . . .	5.0

Klaproth, Beit. b. ii. s. 221.

Geognostic and Geographic Situations.—It occurs principally in veins in primitive rocks in Cornwall, and other countries.

Genus VII. CERIUM-ORE.

Cerer-erz, *Mohs.*

Cleavage either prismatic or invisible. No metallic lustre. Streak white, grey. Hardness = 5.5. Sp. gr. = 3 5 —5.0.

1. Prismatic Cerium-Ore, *Jameson.*

Prism = 117°. Sp. gr. = 4.0—5.3.

External Characters.—Colour brownish-black. Occurs massive, and crystallized in oblique four, and in six-sided prisms. Internally shining, and resino-metallic. Fracture conchoidal. Opaque. Affords a greenish-grey coloured streak.

Geognostic and Geographic Situations.—Occurs in a granite rock in West Greenland, where it was first discovered by Professor Giesecké of Dublin.

2. Uncleavable Cerium-Ore, or Cerite, *Jameson.*—Untheilbares Cerer-erz, *Mohs.*

Massive. Hardness = 5.5. Sp. gr. = 4.6, 5 0.

External Characters.—Colour red and brown. Occurs massive, and disseminated. Internally glimmering and resinous. Fracture fine splintery. Opaque. Its streak is greyish-white.

Constituent Parts.—	Oxide of Cerium,	54.50
	Silica, . .	34.50
	Oxide of Iron,	3.50
	Lime, . .	1.25
	Water, .	5.00—98.75

Klaproth, Beit. b. iv. s. 147.

Geognostic and Geographic Situations.—Occurs in a bed of copper-pyrites, in Westmanland in Sweden.

Genus VIII. CHROME-ORE.

Chrom-erz, *Mohs.*

Prismatic. Streak brown. Hardness = 5.5. Sp. gr. = 4.4,—4.5.

This genus contains one species, viz. Prismatic Chrome-Ore.

1. Prismatic Chrome-Ore, *Jameson.*—Prismatisches Chrom-erz, *Mohs.*

Prismatic. Pyramid unknown. Cleavage prismatoidal.

External Characters.—Colour between steel-grey and iron-black. Occurs massive, disseminated, and in granular distinct concretions; also crystallized in oblique four-sided prisms, acuminated with four planes. Internally shining or glistening, and the lustre imperfect metallic. Fracture small and fine-grained uneven, sometimes passing into small and imperfect conchoidal. Opaque.

Physical Characters.—Some varieties are magnetical, others are not.

Chemical Characters.—It is infusible before the blowpipe. Melted with borax, it forms a beautiful green-coloured mass, very different from the dark green-coloured glass formed when borax and magnetic iron-ore are melted.

		Stiria.
Constituent Parts.—	Oxide of Iron,	33.00
	Oxide of Chrome,	55.50
	Alumina, .	6.00
	Silica, . .	2.00
	Loss by heating,	2.00—98.50

Klaproth, Beit. b. iv. s. 132.

Geognostic and Geographic Situations.—Occurs in serpentine and talc in the Shetland islands, and in various quarters in the continents of Europe, Asia, and America.

Uses.—When the chromic acid, which this ore contains, is combined with lead, it forms an uncommonly beautiful yellow pigment.

Genus IX.—IRON-ORE.

Eisen-erz, *Mohs.*

Tessular, rhomboidal, prismatic. Hardness = 5, 6.5. Sp. gr. = 3.8, 5.2. If the streak is brown, the Sp.

gr. is below 4.2, or above 4.8. If the streak is black, the Sp. gr. is above 4.8.

1. Octahedral Iron-Ore.—Octaedrisches Eisenerz, *Mohs*. Fer Oxydulé, *Hauy*.

Tessular. Cleavage octahedral. Streak black. Hardness = 5.5, 6.5. Sp. gr. = 4.8,—5.2.

This species is divided into two subspecies, viz. Common Magnetic Iron-Ore, and Granular Magnetic Iron-Ore.

First Subspecies.

Commom Magnetic Iron-Ore, *Jameson*.—Gemeiner Magneteisenstein, *Werner*.

External Characters.—Colour iron-black. Occurs massive, disseminated, in distinct concretions, and crystallized in octahedrons and rhomboidal dodecahedrons. Externally shining, glistening, or splendent. Internally intermediate between shining and glistening, and lustre metallic. Fracture uneven.

Physical Characters.—Highly magnetic, with polarity.

Constituent Parts.—	Peroxide of Iron,	69
	Protoxide of Iron,	31—100
		Berzelius.

Geognostic and Geographic Situations.—Occurs principally in beds, in primitive mountains in Norway, Sweden, Lapland, and other countries.

Uses.—When pure, it affords excellent iron.

Second Subspecies.

Granular Magnetic Iron-Ore, or Iron-Sand, *Jameson*.—Eisensand, *Werner*.

External Characters.—Colour very dark iron-black. Occurs in grains, and also in octahedral crystals. The grains have a feeble glimmering, and rough surface. Internally intermediate between shining and splendent, and lustre imperfect metallic. Fracture conchoidal.

Geognostic and Geographic Situations.—Occurs imbedded in trap rocks in different parts of Scotland, and in many countries on the continent of Europe.

2. Rhomboidal Iron-Ore, *Jameson*.—Rhomboedrisches Eisen-erz, *Mohs*. Fer Oligiste, *Hauy*.

Rhomboid = 85° 58′. Cleavage rhomboidal, and parallel with terminal planes of six-sided prisms. Streak red, reddish-brown. Hardness = 5.5.—6.5. Sp. gr. = 4.8.—5.2.

This species is divided into three subspecies, viz. 1. Specular Iron-ore, or Iron-glance, 2. Red Iron-ore, 3. Red Clay Iron-ore.

First Subspecies.

Specular Iron-Ore, *Jameson*.

This Subspecies is divided into two kinds, viz. Common Specular Iron-ore, and Micaceous Specular Iron-ore.

First Kind.—Common Specular Iron-Ore, *Jameson*.—Gemeiner Eisenglanz, *Werner*.

External Characters.—Colour dark steel-grey, which frequently borders on iron-black, and sometimes inclines to brownish-red. Occurs very frequently tarnished on the external surface. Occurs massive, disseminated, in concretions, and also crystallized in rhomboids and in six-sided pyramids. Internally glistening, but sometimes passes into shining and splendent, and the lustre metallic. Fracture conchoidal.

		From Grengesberget.
Constit. Parts.—	Reddish-brown Oxide of iron,	94.38
	Phosphate of Lime, . .	2.75
	Magnesia, . . .	0.16
	Mineral Oil, . . .	1.25
	Loss by heating, . .	0.50
		98.94

Hisinger, Afhandlingar, iii. p. 32, 33.

Geognostic and Geographic Situations.—Generally occurs in beds, in primitive and secondary rocks; as in England, and in many mines in the continents of Europe, Asia, and America.

Uses.—When it occurs in quantity, it is smelted as an ore of iron, and affords excellent malleable iron.

Second Kind.—Micaceous Specular Iron-Ore, *Jameson*.—Eisenglimmer, *Werner*.

External Characters.—Colour iron-black. Occurs most commonly massive and disseminated. Internally splendent, which in some varieties passes into shining, and the lustre is metallic. Slightly translucent on the edges; but translucent in thin plates, and it then appears blood-red.

Geognostic and Geographic Situations.—Generally occurs in primitive rocks, and it is met with in Scotland, England, Norway, Germany, &c.

Uses.—It melts better than common specular iron-ore, but requires a greater addition of limestone. The iron which it affords is sometimes cold-short, but is well fitted for cast-ware.

Second Subspecies.

Red Iron-Ore, *Jameson*.—Rotheisenstein, *Werner*.

This species is divided into four kinds, viz. Scaly Red Iron-ore, Ochry Red Iron-ore, Compact Red Iron-ore, and Fibrous Red Iron-ore or Red Hematite. Of these the principal kinds are the compact and fibrous.

Compact Red Iron-ore, *Jameson*.—Dichter Rotheisenstein, *Werner*.

External Characters.—Colour intermediate between dark steel-grey and blood-red. Occurs most commonly massive, sometimes also disseminated, specular, with impressions; and in supposititious crystals. Fracture usually uneven.

Constituent Parts.—	Oxide of Iron,	70.50
	Oxygen,	29.50—100.00

Bucholz in Ghelen's Journ. b iii. s. 158.

Geognostic and Geographic Situations.—Occurs in beds and veins in primitive mountains in England, Norway, Sweden, Germany, &c.

Uses.—It affords good cast and bar-iron.

Fibrous Red Iron-Ore, or Red Hematite, *Jameson*.—Rother Glaskopf, *Werner*.

External Characters.—Colours blood red and dark steel-grey. Occurs most frequently massive, reniform, botryoidal, stalactitic, and globular; also in fibrous and lamellar distinct concretions.

Const. Parts.—	Oxide of Iron, . .	90
	Trace of Oxide of Manganese,	
	Silica, ...	2
	Lime, ...	1
	Water, ...	3—96

Daubuisson, Ann. de Chimie, Sept. 1810.

Geognostic and Geographic Situations.—These are the same as the preceding.

Uses.—It affords excellent malleable and cast-iron.

THIRD SUBSPECIES.

RED CLAY IRON-ORE or STONE, *Jameson.*

This subspecies is divided into four kinds, viz. Ochry Red Clay Iron-ore, Columnar Red Clay Iron-ore, Lenticular Red Clay Iron-ore, and Jaspery Red Clay Iron-ore.

First Kind. OCHRY RED CLAY IRON-ORE, or RED CHALK. *Jameson* —Roethel, *Werner.*

External Characters.—Colour brownish-red. Occurs massive. Principal fracture glimmering; cross fracture dull. Principal fracture thick slaty; cross fracture fine earthy. Fragments sometimes tabular, and sometimes splintery.

Geognostic and Geographic Situations.—It occurs in thin beds in clay-slate and grey-wacke-slate in Hessia, Thuringia, &c.

Uses.—It is principally used for drawing. The coarser varieties are used by the carpenter, the finer by the painter.

Second Kind. COLUMNAR RED CLAY IRON-ORE, *Jameson.*—Stänglicher Thoneisenstein, *Werner.*

External Characters.—Colour brownish-red. Occurs massive, and in columnar distinct concretions.

Geognostic and Geographic Situations.—It is a rare mineral, and is in general a pseudo-volcanic production. It is found in Germany and other countries.

Third Kind. LENTICULAR RED CLAY IRON-ORE, *Jameson.*—Linsenförmiger Thoneisenstein, *Werner.*

External Characters.—Colours brownish-red and reddish-brown. Occurs massive, and in lenticular concretions.

Geognostic and Geographic Situations.—It occurs principally in beds in an amygdaloid, subordinate to clay-slate and grey-wacke in Bohemia.

Fourth Kind. JASPERY RED CLAY IRON-ORE, *Jameson.*—Jaspisartiger Thoneisenstein, *Werner.*

External Characters.—Colour reddish-brown. Occurs massive. Internally feebly glimmering, sometimes approaching to glistening. Fracture large and flat conchoidal.

Geognostic and Geographic Situations.—It occurs at Fischau in Austria, where it forms considerable beds in a flœtz or secondary formation.

3. PRISMATIC IRON-ORE, *Jameson.*—Prismatisches Eisen-erz, *Mohs.* Braun Eisenstein, *Werner.*

Prismatic. Pyramid unknown. Streak yellowish-brown. Hardness = 5.5. Sp. gr. = 3.8.—4.2.

This species is divided into four subspecies, Ochry Brown Iron-ore, Compact Brown Iron-ore, Fibrous Brown Iron-ore or Brown Hematite, Brown Clay Iron-ore. * Bog Iron-ore.

FIRST SUBSPECIES.

OCHRY BROWN IRON-ORE, *Jameson.* Ockriger Brauneisenstein, *Werner.*

External Characters.—Colour light yellowish-brown. Occurs massive and disseminated. Internally dull. Fracture coarse earthy. Soils slightly.

Geognostic and Geographic Situations.—It occurs along with the compact and fibrous subspecies, in England, Germany, France, &c.

Use.—It affords excellent bar-iron.

SECOND SUBSPECIES.

COMPACT BROWN IRON-ORE, *Jameson.* Dichter Brauneisenstein, *Werner.*

External Characters.—Colours yellowish-brown and clove-brown. Occurs massive, and disseminated; very rarely in supposititious crystals. Internally dull, or semimetallic glimmering. Fracture even, sometimes also fine-grained uneven. Streak yellowish-brown.

		Bergzabern.
Constit. Parts.—	Peroxide of Iron, .	84
	Water, . . .	11
	Oxide of Manganese, .	1
	Silica, ...	2—98

Daubuisson, Annal. de Chim.

Geognostic and Geographic Situations.—It occurs in the same geognostic and geographic situations as the following subspecies.

Uses.—It affords about 50 *per cent.* of Iron. It is easily fusible. It affords excellent bar-iron.

THIRD SUBSPECIES.

FIBROUS BROWN IRON-ORE, or BROWN HEMATITE, *Jameson.* Brauner Glaskopf, *Werner.*

External Characters.—Colour brown. Seldom occurs massive, more frequently stalactitic, coralloidal, reniform, botryoidal, tuberose; sometimes also cylindrical, fructicose, and in distinct concretions, which are fibrous, granular and lamellar. Internally glimmering; lustre intermediate between pearly and resinous.

		Fibrous Bergzabern.
Constit. Parts.—	Peroxide of Iron, .	79
	Water, . . .	15
	Oxide of Manganese,	2
	Silica, . . .	3—99

Geognostic and Geographic Situations.—Occurs in primitive, transition, and secondary mountains, in England, Germany, Italy, &c.

FOURTH SUBSPECIES.

BROWN CLAY IRON-ORE, *Jameson.*

This subspecies is divided into five kinds, viz. Common Brown Clay Iron-ore, Pisiform Brown Clay Iron-ore, Reniform Brown Clay Iron-ore, Granular Brown Clay Iron-ore, and Umber.

First Kind. COMMON BROWN CLAY IRON-ORE. *Jameson.*

External Characters.—Colours brown and yellow. Occurs massive. Internally dull or feebly glimmering. Fracture conchoidal; also even and uneven. Streak brown.

Constituent Parts.—	Oxide of Iron, .	69
	Oxide of Manganese,	3
	Water, . . .	13
	Silica, . . .	10
	Alumina, . .	3—98

Daubuisson, Annal. de Chim. Sept. 1810.

Geognostic and Geographic Situations.—It occurs in England; also in Saxony, Bohemia, Silesia, and Westphalia, in beds in secondary rocks.

Second Kind. PISIFORM BROWN IRON-ORE or PEA-ORE, *Jameson.* Bohnerz, *Werner.*

External Characters.—Colour yellowish-brown. Occurs in small spherical round grains, which are not hollow, and these are composed of concentric curved lamellar concretions.

Geognostic and Geographic Situations.—It occurs in hollows in secondary rocks, as at Galston in Ayrshire, and in many places on the Continent of Europe.

Uses.—It yields from 30 to 40 *per cent.* of Iron.

Third Kind. RENIFORM OR KIDNEY-SHAPED BROWN CLAY IRON-ORE, *Jameson.* Eisenniere, *Werner.*

External Characters.—Colour yellowish-brown. Occurs massive, in irregular single balls, also in reniform, lenticular and elliptical forms, which are sometimes hollow. These forms are composed of concentric lamellar concretions, which often include a loose nodule.

Geognostic and Geographic Situations.—It occurs imbedded in ironshot clay, in secondary rocks of different kinds, and also in loam and clay beds that lie over black coal.

Uses.—It is one of the best kinds of ironstone, yields an excellent iron, and is smelted in many places.

Fourth Kind. GRANULAR BROWN CLAY IRON-ORE, *Jameson.*

External Characters.—Colours yellowish and reddish brown. Occurs massive, and in small globular united grains.

Geognostic and Geographic Situations.—It occurs in beds between the red sandstone of the salt formation and the lias limestone. It often contains petrifactions of shells. It is found in Bavaria, Salzburg, the Tyrol, and France.

Uses.—It affords about 40 *per cent.* of good iron.

Fifth Kind. UMBER, *Jameson.*

External Characters.—Colours clove-brown and yellowish-brown. Occurs massive. Internally dull or glimmering, and resinous. Fracture flat conchoidal.

Geognostic and Geographic Situations.—It occurs in beds in the Island of Cyprus.

Use.—It is used as a pigment.

*BOG IRON-ORE, *Jameson.* Raseneisenstein, *Werner.*

There are three kinds of this ore, viz. Morass-ore, Swamp-ore, and Meadow-ore.

First Kind. MORASS-ORE, OR FRIABLE BOG IRON-ORE, *Jameson.* Morasterz, *Werner.*

External Characters.—Colour brown. Sometimes friable, sometimes nearly coherent. Coherent varieties occur massive, corroded, in grains, and sometimes tuberose. The friable is composed of dull dusty particles. Coherent varieties externally and internally dull. Fracture earthy.

Observations.—It is characterised by colour, dull earthy aspect, and low specific gravity.

Second Kind. SWAMP-ORE, OR INDURATED BOG IRON-ORE, *Jameson.* Sumpferz, *Werner.*

External Characters.—Colour yellowish-brown. Occurs corroded and vesicular, also amorphous. Internally dull, but the darker varieties glimmering, and sometimes even glistening. Fracture earthy, sometimes passing into fine-grained uneven. Specific gravity, 2.944, from Sprottau, *Kirwan.*

Observations.—It is distinguished from the preceding kind, by its greater specific gravity, and greater compactness.

Third Kind. MEADOW-ORE, OR CONCHOIDAL BOG IRON-ORE, *Jameson.* Weisenerz, *Werner.*

External Characters.—On the fresh fracture it is blackish-brown, which sometimes passes into brownish-black. Occurs massive. Internally shining; glistening; lustre resinous. Fracture conchoidal. Yields a light yellowish-grey streak.

Constituent Parts.

Oxide of Iron,	61.0
Oxide of Manganese,	7.0
Phosphoric Acid, with a trace of Sulphur,	2.5
Water,	19.0
Silica,	6.0
Alumina,	2.0—97.5

Daubuisson, Annal. de Chim. 1800.

Geognostic and Geographic Situations of Bog-iron ore.—It is found in various places in the Highlands of Scotland, in the Hebrides, and Orkney and Shetland Islands, in alluvial soil. Also abundantly on the continents of Europe and America.

Uses.—Affords good iron on smelting.

GENUS X. MANGANESE-ORE.

Mangan-erz, *Mohs.*

Prismatic. Hardness =2.5—6. Sp. gr. =4.3—4.8.

This genus contains but one species, viz. Prismatic Manganese ore.

1. PRISMATIC MANGANESE-ORE, *Jameson.*—Prismatisches Mangan-erz, *Mohs.*

Prism nearly 100°. Most perfect cleavage in direction of the longer diagonal.

This species contains three subspecies, viz. Grey Manganese-ore, Black Manganese-ore, and Scaly Brown Manganese-ore.

FIRST SUBSPECIES.

GREY MANGANESE-ORE, *Jameson.*—Grau Braunsteinerz, *Werner.*

External Characters.—Colour dark steel-grey, inclining more or less to iron-black. Occurs massive, in various particular external shapes, in fibrous and radiated concretions, and crystallized in four-sided prisms. Lustre shining, glimmering, and metallic; fracture conchoidal and earthy. Streak black.

Const. Parts.—Black Oxide of Manganese,		90.50
	Oxygen,	2.25
	Water,	7.00
	Klaproth,	100.

Geognostic and Geographic Situations.—Occurs in veins and imbedded masses in primitive rocks in Scotland, England, France, and Germany.

Uses.—It is added to glass, in small quantity, when we wish to destroy the brown colour which that material receives from intermixed inflammable substances, or in larger quantity, when we wish to give to it a violet blue colour. It affords a fine brown colour, which is used for painting on porcelain. It is employed in the laboratory, as the cheapest and most convenient material from which to procure oxygen gas. All the oxymuriatic acid used in bleacheries, and for the purpose of destroying contagious matter, is prepared from manganese, and the usual materials of muriatic acid.

SECOND SUBSPECIES.

BLACK MANGANESE-ORE, *Jameson.*

External Characters.—Colours bluish-black and steel-grey. Occurs massive, tuberose, fruticose, reniform, and botryoidal; also in fibrous and lamellar concretions. Internally glimmering, glistening, and metallic. Fracture conchoidal. Opaque. Streak blackish-brown.

Geognostic and Geographic Situations.—Occurs in veins in primitive, transition, and secondary rocks, in Saxony, Hanover, &c.

THIRD SUBSPECIES.

SCALY BROWN MANGANESE-ORE, *Jameson.*—Brauner Eisenrahm, *Werner.*

External Characters.—Colour intermediate between steel-grey and clove-brown. Occurs in crusts, massive, spumous, fruticose, and irregular dendritic. Friable, or friable passing into solid. Composed of scaly particles, which are intermediate between shining and glistening, with metallic lustre. Soils strongly. Feels greasy.

Geognostic Situation.—Occurs in drusy cavities in brown hematite.

Geographic Situation.—It is found near Sandlodge in Mainland, one of the Shetland Islands; and in various iron mines on the Continent of Europe.

ORDER IX.—NATIVE METALS.

Metallic. Not black. If grey, is ductile; and Sp. gr. =7.4. and more. Hardness =0. — 4, or malleable. Sp. gr. =5.7—2.0.

GENUS I. ARSENIC.

Form unknown. Tin white. Hardness =3.6. Sp. gr. =5.7—5.8.

1. NATIVE ARSENIC, *Jameson.* Gediegen Arsenik, *Werner and Mohs.*

Reniform and massive.

External Characters.—Colour tin white. Internally, on the fresh fracture, usually glistening, inclining to glimmering, sometimes to shining, and the lustre metallic. Fracture small, and fine-grained uneven.

Chemical Characters.—Before the blowpipe it yields a white smoke, diffuses an arsenical odour, burns with a blue flame, is gradually and almost entirely volatilized, and deposits a white coating on the coal.

Const. Parts.—It usually contains a small portion of iron, and when it occurs with gold or silver, a little gold or silver.

Geognostic and Geographic Situations.—It occurs in veins in primitive rocks, as in gneiss, mica-slate, and clay-slate, and less frequently in transition and secondary rocks, in Norway, Germany, France, Spain, &c.

GENUS II. TELLURIUM.

Form unknown. Tin-white. Hardness = 2—2.5. Sp. gr. =6.1, 6.2.

This genus contains one species, viz. Native Tellurium.

1. NATIVE TELLURIUM, *Jameson.* Hexahaedrisches Tellur, *Mohs.* Gediegen Sylvan, *Werner.*

Massive.

External Characters.—Colour tin-white. Occurs massive. Internally shining, and lustre metallic.

Constit. Parts.—	Tellurium,	92.55
	Iron,	7.20
	Gold,	0.25—100.00

Klaproth, Beit. b. iii. s. 8.

Geognostic and Geographic Situations.—It occurs in veins in grey-wacke, in Transylvania.

GENUS III. ANTIMONY.

Tessular, prismatic. Not ductile. White. Hardness =3—3.5. Sp. gr. =6.5—10.

This Genus contains two species, viz. Dodecahedral Antimony, and Octahedral Antimony.

1. DODECAHEDRAL ANTIMONY, *Jameson.*—Dodecaedrisches Spiesglas, *Mohs.* Gediegen Spiesglas, *Werner.*

Tessular. Cleavage octahedral and dodecahedral. Hardness =3—3.5. Sp. gr. =6.5—6.8.

External Characters.—Colour perfect tin-white. Occurs massive, disseminated, reniform; also in granular and lamellar distinct concretions. Crystallized, in octahedrons and rhomboidal dodecahedrons. Splendent and metallic.

Geognostic and Geographic Situations.—It is found in argentiferous veins in the gneiss mountain of Chalanches in Dauphiny.

2. OCTAHEDRAL ANTIMONY, *Jameson.*—Octaedrisches Spiesglas, *Mohs.*

Tessular. Cleavage octahedral. Hardness 3.5. Sp. gr. =8.9,—10.

Two Subspecies, viz. 1. Antimonial Silver, 2. Arsenical Silver.

FIRST SUBSPECIES.

ANTIMONIAL SILVER, *Jameson.*—Spiesglas Silber, *Werner.*

External Characters—Colour intermediate between silver-white and tin-white. Occurs massive, and crystallized in oblique four and in six-sided prisms. Internally shining and splendent, with metallic lustre.

Geognostic and Geographic Situations.—It occurs in veins, in primitive and transition rocks, in Germany and France.

Observations.—The oblique prism, if accurately given, would refer this subspecies to the prismatic series.

SECOND SUBSPECIES.

ARSENICAL SILVER, *Jameson.* Arsenik Silber, *Werner.*

External Characters.—Colour on the fresh surface tin-white, which tarnishes greyish-black. Occurs massive, reniform, and in lamellar concretions. Internally glistening and metallic. Fracture uneven.

Const. Parts.	Arsenic,	35.00
	Iron,	44.25
	Silver,	12.75
	Antimony,	4.00—96.00

Klaproth, Beit. b. i. s. 187.

Geognostic and Geographic Situations.—It occurs in veins in primitive and transition rocks, in Germany and Spain.

GENUS IV.—BISMUTH.

Tessular. Silver-white, inclining to red. Hardness =2.0,—2.5. Specific gravity=8.5, 9.

This genus contains one species, viz. Octahedral Bismuth.

1. OCTAHEDRAL BISMUTH, *Jameson.* Octaedrisches Wismuth, *Mohs.* Gediegen Wismuth, *Werner.*

Tessular. Cleavage octahedral.

External Characters.—Colour silver-white, which inclines to red. Seldom massive, generally disseminated, and in leaves having plumosely-streaked surfaces, and crystallized in octahedrons, cubes, and tetrahedrons. Internally splendent, and lustre metallic. Malleable.

Geognostic and Geographic Situations.—It occurs in veins in primitive rocks in Cornwall, and other countries.

Uses.—It enters as an ingredient into the composition of printing types, and of pewter; is used as solder, in the construction of mirrors, and for the refining of gold and silver; its oxide is used as a white pigment, as an essential ingredient in a kind of salve, which is used for giving a black colour to the hair, and as an ingredient in sympathetic ink. All the bismuth of commerce is obtained from Saxony.

Genus. V. MERCURY.

Tessular, liquid. Not malleable. White. Hardness =0—3. Specific gravity=10.5—15.

This genus contains two species, viz. 1. Fluid Mercury, 2. Dodecahedral Mercury.

1. Liquid Native Mercury. *Jameson.* Tropfbares Gediegen Quecksilber, *Mohs.* Gediegen Quecksilber, *Werner*

Liquid. Tin-white. Hardness=0. Specific gravity=12—15.

External Characters.—Colour tin-white. Perfectly liquid. Splendent, and lustre metallic.

Geognostic and Geographic Situations.—This mineral occurs principally in rocks of the coal formation, and either disseminated, or in veins traversing them, as in Spain and Germany.

2. Dodecahedral Mercury, or Native Amalgam, *Jameson.* Natürliches Amalgam, *Werner.*

Tessular. No cleavage. Silver-white. Hardness= 1—3 Specific gravity=10 5—12.5

External Characters.—Colour silver-white. Occurs usually in small roundish portions; and crystallized in rhomboidal dodecahedrons. Internally shining and metallic. Fracture small-grained uneven. When pressed between the fingers, or cut with a knife, it emits a creaking sound like artificial amalgam.

Constituent Parts.—Mercury . 74
Silver . 25—99
Heyer, in Crell's Annalen, 1790, b. ii. s. 36. 44.

Geognostic and Geographic Situations.—It is generally associated with native mercury and cinnabar. It is found at Moschellandsberg in Deux-Ponts; and, it is said, also at Rosenau in Hungary.

Genus VI. SILVER.

Tessular. Malleable. Silver-white. Specific gravity=10—10.5.

1. Hexahedral Silver, *Jameson.* Hexaedrisches Silber. *Mohs.*

Tessular. No cleavage.

This species is divided into two subspecies, viz. Common Native Silver, and Auriferous Native Silver.

First Subspecies.

Common Native Silver, *Jameson.*

External Characters.—Colour pure silver-white. Seldom occurs massive, more frequently disseminated, and in various particular external shapes, or crystallized in cubes, octahedrons, rhomboidal, dodecahedrons, and tetrahedrons. Lustre splendent to glimmering. Fracture fine hackly.

Geognostic and Geographic Situations.—Occurs in veins in various silver-mines in Europe, Asia, Africa, and America.

Uses.—Its various uses, in coinage, and for other useful and ornamental purposes, will be considered in a separate article.

Second Subspecies.

Auriferous Native Silver, *Jameson.* Guldischesgediegen Silber. *Werner*

External Characters.—Colour intermediate between brass-yellow and silver-white.

Constituent Parts. Silver . 72.00
Gold . . 28.00—100 00
Fordyce. Phil. Trans. 1799, p. 523.

Geognostic and Geographic Situations.—It occurs in veins in primitive rocks at Kongsberg in Norway; at Rauris in Salsburg; and at Schlangenberg in Siberia.

Genus VII. GOLD.

Tessular. Yellow. Specific gravity=12—20.

This genus contains only one species, viz. Hexahedral Gold.

1. Hexahedral Gold *Jameson.* Hexaedrisches Gediegen Gold, *Mohs.* Gediegen Gold, *Werner.*

Tessular. No cleavage.

External Characters.—Colour perfect gold-yellow, which varies in intensity; in some varieties inclines to brass-yellow. Seldom occurs massive, often disseminated, and sometimes crystallized in octahedrons, cubes, rhomboidal dodecahedrons, and tetrahedrons. Internally shining, glistening, and metallic. Fracture hackly.

Geognostic and Geographic Situations.—It occurs in veins, and disseminated in primitive transition and secondary rocks, abundantly in alluvial deposites, and is not confined to any particular quarter of the globe, being found in Europe, Asia, Africa, and America.

Genus VIII. PLATINA.

Form unknown. Steel-grey. Sp. gr. = 16—20.

1. Native Platina.—*Jameson.*—Gediegen Platin, *Werner*

In grains and rolled pieces.

External Characters.—Colour very light steel-grey, which approaches to silver-white. Occurs in grains and rolled pieces. Roundish. Externally shining, glistening, or glimmering, and lustre metallic.

Geognostic and Geographic Situations.—Occurs principally in alluvial deposites in South America.

Genus IX. IRON.

Tessular. Pale steel-grey. Sp. gr.=7.4—7.8.

This genus contains one species, viz. Octahedral Iron.

1. Octahedral Iron.—*Jameson.*—Octaedrisches Eisen, *Mohs.*—Gediegen Eisen, *Werner.*

Tessular. No cleavage.

This species is divided into two subspecies, viz. Terrestrial Native Iron, and Meteoric Native Iron.

First Subspecies.

Terrestrial Native Iron, *Jameson.*—Tellureisen, *Werner.*

External Characters.—Colour steel-grey. Occurs massive, in plates, and in leaves. Internally glistening, and lustre metallic. Fracture hackly.

Constituent Parts.—Iron,	. .	92.50
Lead,	. .	6.00
Copper,	.	1.50—100.00

Klaproth, Beit. b. iv. s. 106.

Geognostic and Geographic Situation.—It is said to have been found associated with brown ironstone, sparry iron, and heavy-spar, at Kamsdorf in Saxony.

SECOND SUBSPECIES.

METEORIC NATIVE IRON, *Jameson.*—Meteoreisen, *Karsten.*

External Characters.—Colour pale steel-grey. Occurs ramose, imperfect globular, and disseminated in meteoric stones. Internally intermediate between glimmering and glistening, and lustre metallic. Fracture hackly. Yields a splendent streak. It is flexible, but not elastic.

		Agram.
Constituent Parts.—Iron,	.	96.5
Nickel,	.	3 5—100.0

Klaproth, Beit. b. iv.

Geographic Situation.—This subspecies of iron falls from the air in all parts of the world, and appears to be formed in the atmosphere by some process hitherto unknown to us.

GENUS X. COPPER.

Tessular. Copper red. Sp. gr. = 8.4 — 8.9.

1. OCTAHEDRAL COPPER, *Jameson.*—Octaedrisches Kupfer, *Mohs.* Gediegen Kupfer, *Werner.*

Tessular. No cleavage.

External Characters.—Colour copper-red. Occurs massive, disseminated, in various particular forms, and crystallized in cubes, octahedrons, and rhomboidal dodecahedrons. Internally glistening, and lustre metallic. Fracture hackly.

Geognostic and Geographic Situations.—It occurs in veins, and imbedded in various primitive, transition, and secondary rocks; also in large blocks in alluvial districts in Europe, Asia, Africa, and America.

ORDER X. PYRITES.

Metallic. Hardness = 3.5—6.5. If hardness 4.5, and less, the sp. gr. is less than 5. Sp. gr. = 4.1 — 7.7. If 5 3, and less, it is yellow-red.

GENUS I. NICKEL PYRITES, OR COPPER-NICKEL, *Jameson.*—Nickelkies, *Mohs.*

Prismatic. Pyramid unknown. Hardness=5—5.5. Sp. gr. =7 5—7.7.

This Genus contains one species, viz. Prismatic Nickel Pyrites.

1. PRISMATIC NICKEL PYRITES, *Jameson.*—Prismatischer Nickelkies, *Mohs.* Kupfer Nickel, *Werner.*

Prismatic. Pyramid unknown. Copper-red.

External Characters.—Colour copper-red. Occurs most frequently massive and disseminated; seldom in particular external forms, and rarely crystallized in oblique four-sided prisms. Internally alternates from shining to glistening, and lustre metallic. Fracture conchoidal, sometimes passing into uneven.

Constit. Parts.—It is a compound of Nickel and Arsenic, with accidental intermixtures of cobalt, iron, and sulphur.

Geognostic and Geographic Situations.—It occurs in primitive, transition, and secondary rocks, in Scotland, and in several different mining districts in Germany and Spain.

GENUS II. ARSENICAL PYRITES.

Prismatic. If white, the sp. gr. 6 2 and less; if grey, sp. gr. above 6.8. Hardness = 5—6. Sp. gr. = 5.7—7.4.

1. PRISMATIC ARSENICAL PYRITES, *Jameson.* Prismatischer Arsenikkies, *Mohs.* Arsenikkies, *Werner.*

Prism unknown. Cleavage unknown. Steel-grey. Hardness = 5.0—5.5 Sp. gr. = 6.9—7.4.

External Characters.—Colour pale steel-grey. Occurs massive, and in the form of oblique four-sided prisms. Lustre metallic and shining.

2. DI-PRISMATIC ARSENICAL PYRITES, *Jameson.*—Di-prismatischer Arsenikkies, *Mohs.*

Prismatic. Hardness=5.5—6.0. Sp. gr.=5.7—6.2.

External Characters.—Colour silver-white. Occurs massive, and disseminated; also in prismatic distinct concretions, and crystallized in oblique four-sided prisms, variously modified by bevelments and truncations. Externally shining or splendent; internally shining, seldom glistening, and lustre metallic. Fracture uneven.

Geognostic and Geographic Situations.—It occurs in primitive, transition, and secondary rocks in Scotland, England, Saxony, Spain, and other countries.

Use. It is from this ore that the White Oxide of Arsenic is principally obtained, and Artificial Orpiment is also prepared from it. A variety named Argentiferous contains a portion of silver.

GENUS III. COBALT-PYRITES.

Tessular. Hardness = 5.5. Sp. gr. 6, = 6 6.

1. HEXAHEDRAL COBALT-PYRITES, OR SILVER-WHITE COBALT, *Jameson.* Hexaedrischer Kobalt-Kies, *Mohs.* Glanz Kobold, *Werner.*

Tessular. Cleavage hexahedral and perfect. White, inclining to red. Hardness = 5.5. Sp. gr. = 6.1—6.3.

External Characters.—Colour silver-white, slightly inclining to copper-red. Occurs commonly massive, and disseminated; also crystallized in cubes, octahedrons, pentagonal dodecahedrons, and icosahedrons. Internally shining and glistening, and lustre metallic. Fracture conchoidal.

Geognostic and Geographic Situations.—It occurs in primitive rocks, in Norway, Sweden, and Silesia.

Use. This is one of the most common species of cobalt, and is that from which the cobalt of commerce is principally obtained.

2. OCTAHEDRAL COBALT-PYRITES, *Jameson.* Octaedrischer Cobalt-Kies, *Mohs.*

Tessular. Cleavage tessular. White, inclining to steel-grey. Hardness = 5.5. Sp. gr. = 6—6.6.

External Characters.—Colours tin-white, inclining more or less to steel-grey. Occurs massive, in various particular external forms, in radiated and lamellar concretions, and crystallized in cubes, octahedrons, and rhomboidal dodecahedrons. Lustre varies, from splendent to glimmering, and is metallic. Fracture uneven, and conchoidal.

		From Riegelsdorf.
Const. Parts.—Arsenic,	.	74.2174
Cobalt, .	.	20.3135
Iron, .	.	3.4257
Copper, .	.	0.1586
Sulphur,	.	0.8860—100

Strohmeyer.

Geognostic and Geographic Situations.—It occurs in veins and beds in primitive, transition, and secondary rocks, and is found in Cornwall, Germany, France, Poland, Norway, and Sweden.

Genus IV. IRON PYRITES.

Tessular, rhomboidal, prismatic. Yellow. Hardness =3.5—6.5. Sp. gr.=4.4—5.

1. Hexahedral Iron-Pyrites, or Common Iron-Pyrites, *Jameson.*—Hexahaedrischer Eisen-Kies, *Mohs.* Gemeiner Schwefelkies, *Werner.*

Tessular. Cleavage hexahedral. Bronze yellow. Hardness=6—6.5. Sp. gr.=4.7—5.

External Characters.—Colour bronze-yellow. Occurs most commonly massive, disseminated, and globular; also in distinct concretions, and crystallized, in cubes, octahedrons, and in the leucite-form. Internally shining and glistening, and lustre metallic. Fracture uneven, and sometimes conchoidal.

Geognostic and Geographic Situations.—It occurs in primitive, transition, and secondary mountains, in every country.

Uses.—It is never worked as an ore of Iron; it is principally valued on account of the sulphur which can be obtained from it by sublimation, and the iron-vitriol which it affords by exposure to the air, either with or without previous roasting.

2. Prismatic Iron-Pyrites, or Radiated Pyrites, *Jameson.* Prismatischer Eisenkies, *Mohs.*

Prism=106° 36′. Cleavage the same. Bronze yellow. Hardness=6, 6.5. Sp. gr.=4.7—5.

External Characters.—Colour bronze-yellow. Occurs massive, in various particulars, external shapes, in radiated fibrous and lamellar concretions, and crystallized in oblique four-sided prisms, variously modified by bevelling and truncating planes. Lustre varies from shining to glimmering, and is metallic. Fracture uneven, or conchoidal.

Constit. Parts.—Sulphur,	.	53.60
Iron,	.	46.40—100

Hatchett, Phil. Trans. for 1804.

Geognostic and Geographic Situations.—It occurs in primitive, transition, secondary, and alluvial formations; and the different principal varieties are met with in England, Germany, Spain, and other countries.

3. Rhomboidal Iron Pyrites, or Magnetic Pyrites, *Jameson.* Magnetkies, *Werner.*

Di-rhomboidal. Rhomboid unknown. Cleavage in the direction of the terminal planes of a regular six-sided prism; another less distinct parellel with the lateral planes of a six-sided prism. Colour bronze-yellow, inclining to copper-red. Hardness=3.5—4.5. Sp. gr.=4.4—4.7.

External Characters.—Colour intermediate between bronze-yellow and copper-red. Occurs massive, disseminated, in coarse granular concretions; and very rarely crystallized in six-sided prisms and six-sided pyramids. Internally splendent, to glistening, and lustre metallic. Fracture conchoidal, or uneven.

Geognostic and Geographic Situations.—It occurs in beds, and imbedded in primitive and transition mountains along with common iron-pyrites, magnetical iron-ore, and blende, in Scotland, Wales, Germany, &c.

Genus V. COPPER-PYRITES.

Many axes. Cleavage tessular. Brass yellow. Steel grey. Iron black. Hardness=3.0—4.0. Sp. gr.=4.1—4.9.

This genus contains two subspecies, viz. Octahedral Copper-Pyrites, and Tetrahedral Copper-Pyrites.

1. Octahedral Copper-Pyrites, or Yellow Copper Pyrites, *Jameson*—Octaedrischer Kupferkies, *Mohs.*—Kupferkies, *Werner.*

Tessular. Cleavage probably octahedral. Brass yellow. Hardness=3.0—4.0. Sp. gr.=4.1—4.3.

External Characters.—Colour brass-yellow. Occurs massive, disseminated, in various particular external forms, and crystallized in octahedrons and tetrahedrons. Internally shining, which in some varieties passes into glimmering. Lustre metallic. Fracture commonly uneven, sometimes even and conchoidal.

		Cornwall.	
Constit. Parts.—Copper,	.	30	
Iron, .	.	53	
Sulphur,	.	12—95	*Chenevix.*

Geognostic and Geographic Situations.—Is one of the most abundant metalliferous minerals; occurs in almost every kind of repository, in all the great classes of rocks, and has a very extensive geographical range.

Uses.—Nearly one-third of the copper which is obtained by metallurgic operations is extracted from this species.

2. Tetrahedral Copper-Pyrites, *Jameson.*—Tetraedrischer, Kupferkies, *Mohs.*

Tessular. Cleavage probably octahedral. Steel-grey and iron-black. Hardness=3.0—4.0. Sp. gr.=4.4—4.9.

This species is subdivided into two subspecies, viz. Grey Copper and Black Copper.

First Subspecies.

Grey-Copper, *Jameson.*—Fahlerz, *Werner.*—Cuivre gris arsenifère, *Hauy.*

External Characters.—Colour steel-grey. Occurs massive, disseminated, and crystallized in tetrahedrons variously modified. Internally glistening and metallic lustre. Fracture uneven, sometimes conchoidal.

		Freyberg.
Constituent Parts.—Copper,	.	42.50
Iron,	.	27.60
Sulphur,	.	10.00
Arsenic,	.	15.60
Silver,	.	0.90
Antimony,	.	1.50—98.00

Klaproth, Beit. b. iv. s. 52.

Geognostic and Geographic Situations.—It occurs in beds and veins, in primitive, transition, and secondary rocks, in different parts of Scotland and England, and also in many mining districts in other countries.

Uses.—It is valued as an ore of copper; and when it contains silver, is worked as an ore of that metal.

Second Subspecies.

Black Copper, *Jameson.*—Schwarzerz, *Werner.*—Cuivre gris antimonifère, *Hauy.*

External Characters.—Colour iron-black, which sometimes inclines to steel-grey. Occurs massive, disseminated, and crystallized in tetrahedrons variously modified. Internally shining and splendent. Lustre metallic. Fracture conchoidal.

		Kapnik in Transylvania.
Constit. Parts.—Copper,	.	37 75
Antimony,	.	22 00
Sulphur,	.	28.00
Silver,	.	0.25
Iron, .	.	3.25
Zinc, .	.	5.00
Loss, .	.	3.75—100.00

Klaproth, Beit. b. iv. s. 56, 68, 73, and 80.

Geognostic and Geographic Situations.—Occurs in veins that traverse transition rocks at Zilla, in the Clausthal in the Hartz, and in other districts.

Use.—It is worked, both as an ore of copper and as an ore of silver.

Genus VI.—TIN-PYRITES.

Steel-grey, inclining to brass-yellow. Sp. gr.=4.3—5.0.

This genus contains but one species, viz. Common Tin Pyrites.

I. Common Tin Pyrites, *Jameson.*—Zinnkies, *Wer.*

External Characters.—Massive. Colour intermediate between steel-grey and brass-yellow. Occurs massive and disseminated. Internally glistening or shining, and lustre metallic. Fracture uneven, and sometimes conchoidal.

Constituent Parts.—Tin,	.	26.50
Copper,	.	30.00
Iron, .	.	12.00
Sulphur,	.	30.50—99

Klaproth, Beit. b. v. s. 230.

Geognostic and Geographic Situations.—It has been hitherto found only in Cornwall, where it occurs in primitive rocks.

Order IV.—GLANCE.

Metallic. Grey, black. Hardness=1—4. Sp. gr. =4—7.6. If the specific gravity is under 5, with single imperfect cleavages, the colour is lead-grey. If above 7.4, is lead-grey.

Genus I.—COPPER-GLANCE, or VITREOUS COPPER, *Jameson.*

Kupfer-Glanz, *Mohs.*

Cleavage rhomboidal. Blackish lead-grey. Sectile, and nearly malleable. The intensity of the lustre increased in the streak. Hardness=2.5—3.0. Sp. gr.= 5.5—5 8.

This genus contains one species, viz. Rhomboidal Copper glance. * Variegated Copper.

I. Rhomboidal Copper Glance, or Vitreous Copper Ore, *Jameson.*—Kupferglas. *Werner.*

Rhomboid unknown. Cleavage in the direction of lateral planes of a six-sided prism.

External Characters.—Colour blackish lead-grey. Occurs massive, disseminated, and crystallized on six-sided prisms and six-sided pyramids. Internally shining, glistening and glimmering, and metallic. Fracture uneven and conchoidal.

		Siberia.
Constituent Parts.—Copper,	.	78.05
Iron, .	.	2.25
Sulphur,	.	18.50
Silica,	.	0.75—100.00

Klaproth, Beit. b. ii. s. 179.

Geognostic and Geographic Situations.—It occurs in veins and beds in primitive rocks; also in beds in bituminous marl-slate, and in flœtz amygdaloid; and is found in Scotland, England, Germany, Sweden, Hungary, &c.

* Variegated Copper, *Jameson.*—Buntkupfererz, *Werner.*

External Characters.—Its fresh colour is intermediate between copper-red and pinchbeck-brown: it, however, soon acquires a variegated tarnish. Occurs massive, disseminated, and crystallized in six-sided prisms. Internally shining or glistening, and lustre metallic. Fracture conchoidal.

		From Rudelstadt in Silesia.
Constituent Parts.—Copper,	.	58
Sulphur,	.	19
Iron, .	.	18
Oxygen, .	.	5—100

Klaproth, Beit. b. ii. s. 286.

Geognostic and Geographic Situations.—It occurs in veins in primitive, transition, and secondary rocks, in various mining countries, as Cornwall, Arendal, Kongsberg, Thuringia, &c.

Uses.—Copper is extracted from it, but it is not so easily reduced as copper-glance. It yields from 50 to 70 *per cent.* of copper.

Genus II.—SILVER-GLANCE, or VITREOUS SILVER, *Jameson.*

Silber-Glanz, *Mohs.*

Cleavage rhomboidal, or not discernible. Blackish lead-grey, and iron-black. If blackish lead-grey, the specific gravity=6.9 and more. Hardness 2.0—2.5. Sp. gr.=5.7—7.2.

This genus contains two species, viz. Hexahedral Silver Glance, and Rhomboidal Silver Glance.

I. Hexahedral Silver Glance, *Jameson.* Hexaedrischer Silber Glanz, *Mohs.*

Tessular. Cleavage not discernible. Sp. gr.=6.9—7.2.

External Characters.—Colour dark blackish lead-grey. Generally occurs massive, sometimes in various particular external shapes, and crystallized in cubes, octahedrons, and rhomboidal dodecahedrons. Externally shining and glistening. Internally shining and glistening, and lustre metallic. Fracture uneven, conchoidal. Completely malleable. Flexible, but not elastic.

	From Himmelsfürst.
Constituent Parts.—Silver,	85
Sulphur,	15—100. *Klaproth.*

Geognostic and Geographic Situations.—It is one of the most frequent of the ores of silver, and there are few formations of that metal which do not contain it. It occurs in Scotland, England, Germany, and many other mining countries.

Uses.—It is highly valued as an ore of silver.

II. Rhomboidal Silver Glance, or Brittle Silver Glance, *Jameson.*—Sprödglaserz, *Werner.*

Rhomboid unknown. Sp. gr.=5.7—6.1.

External Characters.—Colour intermediate between iron-black and blackish lead-grey. Generally disseminated, and sometimes crystallized in equiangular six-sided prisms, and six-sided pyramids. Externally highly splendent. Internally shining, inclining to glistening, and lustre metallic. Fracture alternates from small conchoidal to fine-grained uneven. Lustre not increased in the streak. Sectile.

Constit. Parts.—Silver,	.	66.50
Sulphur,	.	12.00
Antimony,	.	10.00
Iron, .	.	5.00
Copper and Arsenic,		0.50
Earthy substances,		1.00—95.00

Klaproth. Beit. b. i. s. 166.

Geognostic and Geographic Situations.—It occurs in veins that traverse gneiss, clay-slate, and porphyry, in Saxony, Bohemia, and Hungary.

Genus III.—GALENA, or LEAD-GLANCE.

Tessular. Pure lead-grey. Hardness=2.5. Sp. gr. 7.0—7.6.

This genus contains but one species, viz. Hexahedral Galena.

1. Hexahedral Galena, or Lead-Glance, *Jameson.*—Hexaedrischer Bleiglanz, *Mohs.*

Tessular. Cleavage hexahedral. Hardness=2.5. Sp. gr.=7.0—7.6.

This species is divided into two subspecies, viz. Common Galena, and Compact Galena.

First Subspecies.

Common Galena, or Lead-Glance, *Jameson.*—Gemeiner Bleiglanz, *Werner.*

External Characters.—Colour lead-grey. Occurs massive, in various particular forms, and crystallized in cubes, and octahedrons. Internally specular, splendent, and glistening, and lustre metallic. Fragments cubical. Perfectly sectile. Uncommonly easily frangible.

			Durham.
Constituent Parts.—Lead,	.	.	85.13
Sulphur, .		.	13.02
Iron,	.	.	0.50—98.65

Thomson.

Geognostic and Geographic Situations.—It occurs in veins, beds, and imbedded masses, in primitive, transition, and secondary mountains, in many of the mining districts in Europe, Asia, and America.

Uses.—Nearly all the lead of commerce is obtained from galena.

Second Subspecies.

Compact Galena, or Lead-Glance, *Jameson.*—Bleischweif, *Werner.*

External Characters.—Colour lead-grey. Occurs massive, disseminated, and specular. Internally glimmering, and lustre metallic. Fracture even, which in some varieties passes into flat conchoidal.

Geognostic and Geographic Situations.—It occurs in the same formations, and in the same countries, as Common Galena.

Genus IV.—BLACK TELLURIUM, or TELLURIUM GLANCE.—*Jameson.*

Blätter Glanz, *Mohs.*

Cleavage perfect, according to one direction. Not malleable. Hardness=1—1.5. Sp. gr.=7.0.—7.2.

I. Prismatic Black Tellurium, *Jameson.*—Prismatischer Blätter-glanz, *Mohs.* Nagyagerz, *Werner.*

Blackish lead-grey. Cleavage prismatoidal or axifrangible.

External Characters.—Colour between blackish lead-grey, and iron-black. Occurs massive, disseminated, in leaves, crystallized, in oblique four-sided prisms and four-sided pyramids. Externally splendent, and lustre metallic. Internally shining. It is sectile.

Const. Parts.—Tellurium,	.	.	.	32.2
Lead, .	.	.	.	54.0
Gold, .	.	.	.	9.0
Sulphur,	.	.	.	3.0
Copper,	.	.	.	1.3
Silver,	.	.	.	5—100

Klaproth, Beit. b iii. s. 32.

Geognostic and Geographic Situations.—It occurs in veins that traverse porphyry, at Nagyag in Transylvania.

Use.—It is worked for the gold it contains.

Genus V.—MOLYBDENA.

Molydan Glanz, *Mohs.*

Rhomboidal. Very flexible. Hardness=1.—1.5. Sp. gr.=4.4.—4.6.

I. Rhomboidal Molybdena, *Jameson.*—Rhomboedrischer Molybdän, *Mohs.* Wasserblei, *Werner.*

Di-rhomboidal. Rhomboid unknown. Cleavage parallel with terminal planes of a six-sided prism. Pure lead-grey.

External Characters.—Colour fresh lead-grey. Occurs usually massive, disseminated, in plates, and sometimes crystallized in six-sided prisms. Internally splendent or shining, and lustre metallic. It writes with a bluish-grey streak on paper, but with a greenish-grey streak on porcelain.

Const. Parts.—Molybdena,	.	.	.	60
Sulphur,	.	.	.	40—100

Bucholz in Gehlen's Journ. de Chem. u. Phys. b. iv. s. 603.

Geognostic and Geographic Situations.—It occurs disseminated in granite, gneiss, mica-slate, and chlorite-slate, in Inverness-shire, Aberdeenshire, Cornwall, and Cumberland. Also in Norway and other countries.

Genus VI.—GOLD GLANCE.

Prismatic: not axifrangible. Pure steel-grey. Hardness=1.5—2.0. Sp. gr.=5.7—5.8.

I. Prismatic Gold Glance, *Jameson.*—Prismatischer Gold Glanz, *Mohs.*

Prism unknown. Cleavage prismatic.

External Characters.—Colour steel-grey. Occurs massive, disseminated, in leaves, and crystallized in oblique four-sided prisms. Externally splendent, and lustre metallic. Internally glistening, and lustre metallic. Fracture fine-grained uneven.

Const. Parts.—Tellurium,	.	.	.	60
Gold, .	.	.	.	30
Silver, .	.	.	.	10—100

Klaproth, Beit. b. iii. s. 20.

Geognostic and Geographic Situation.—It occurs in veins in porphyry, in Transylvania.

Use.—It is worked as an ore of gold, and as an ore of silver.

Genus VII.—BISMUTH GLANCE.

Prismatic. Lead-grey. Hardness=2.0—2.5. Sp. gr.=6 1—6.4.

Prismatic Bismuth Glance, *Jameson.* Prismatischer Wismuth Glanz, *Mohs.* Wismuth Glanz, *Werner.*

Prismatic pyramid unknown. Lead-grey. Hardness =2.0—2.5. Sp. gr.=6.1—6.4.

External Characters.—Colour pale lead-grey. Occurs massive, disseminated, in granular and radiated concretions, and crystallized in oblique four-sided prisms. Internally splendent and metallic. Soils. Brittle, inclining to sectile.

Const. Parts.—Bismuth,	. . .	60
Sulphur,	. . .	40—100

Sage in Mem. de l'Acad. d. Sc. 1782, p. 307.

Geognostic and Geographic Situations.—It occurs in veins in Cornwall, Saxony, and other countries.

Genus VIII.—ANTIMONY GLANCE.

Three axes. Prismatic. Lead-grey, inclining to blackish and steel-grey. If it passes into steel-grey, the cleavage is axifrangible, inflexible, sectile. If it passes into lead-grey, is brittle. Hardness=2.0—3.0. Sp. gr. 4.0—5.8.

I. Prismatoidal Antimony Glance, or Grey Antimony. Grau Spiesglaserz, *Werner.* Prismatoidischer Antimon-Glanz, *Mohs.*

Prismatic. Pyramid unknown. Cleavage prismatic. Lead-grey. Hardness=2. Sp. gr.=4.0.—4.6.

External Characters.—Colour lead-grey. Occurs massive, disseminated, in distinct concretions, which are radiated, fibrous, and granular; also crystallized in oblique four-sided prisms, and in six-sided prisms. Lustre from glistening to splendent and metallic. Fracture uneven and even.

Const. Parts.—Antimony 74; Sulphur 26=100. *Bergman.*

Geognostic and Geographic Situations.—Occurs in veins and beds in primitive and transition rocks. In Dumfries-shire there are veins of it in grey-wacke, and in Banffshire it is distributed among rocks of the primitive class. There are considerable deposits of it on the Continent, and also in America.

2. Axifrangible Antimony Glance, or Bournonite. Axentheilender Spiesglas Glanz, *Mohs.*

Prism unknown. Axifrangible. Colour Blackish, lead-grey, passing into steel-grey. Hardness=2.0—2 5. Sp. gr.=5.5—5.8.

External Characters.—Colour blackish lead-grey, passing into steel-grey. Occurs massive, disseminated, and crystallized in oblique four-sided prisms. Externally shining and metallic; internally glistening and metallic. Fracture conchoidal or uneven.

Constituent Parts.—Lead, 42.62; Antimony, 24 23; Copper, 18 20; Iron, 1.20; Sulphur, 17.00 = 100. Hatchett, *Phil Trans* 1804. p. 63.

Geognostic and Geographic Situations.—Found in Cornwall in veins in clay-slate; also in Germany, Siberia and Peru.

3. Prismatic Antimony Glance. Prismatischer Spiesglas-glanz, *Mohs.*

Prism unknown. Cleavage in direction of the shorter diagonal. Blackish lead-grey. Hardness 2.5.—3.0. Sp. gr.=5.7—5.8.

External Characters.—Colour blackish lead-grey. Crystallized in oblique four-sided prisms. Lustre shining and metallic.

Order XII.—BLENDE.

If metallic, the colour is black with a green streak. If not metallic, the lustre is adamantine. If the streak is brown or white, it is tessular, with a hardness between 4 0 and 4.2. If the streak is red, the specific gravity is 4.5. and more, and the hardness 2.5. and less. Hardness= 1. and 4. Sp. gr.=3.9—8.2. If 4.3, and more, the streak is red.

Genus I.—MANGANESE-BLENDE.

Glanz-Blende, *Mohs.* Mangan-Blende, *Werner.*

Three axes. Prismatic. Streak greenish. Hardness =3.5—4 0. Sp. gr.=3.9—4.0.

1. Prismatic Manganese Blende, *Jameson.*—Prismatischer Glanz Blende, *Mohs.*

Prismatic. Pyramid unknown. Cleavage prismatic, but very imperfect. Metallic.

External Characters.—Colour on the fresh fracture iron-black, but on exposure it becomes tarnished of a brownish-black colour. Occurs massive, disseminated, in granular concretions, and crystallized on oblique four-sided prisms. Lustre splendent or shining, and semi-metallic. Opaque. Streak of a greenish colour.

Const. Parts.—Oxide of Manganese,	.	85
Sulphur,	. . .	15—100

Vauquelin, Annal. d. Mus. vi. s. 405.

Geognostic and Geographic Situations.—It is found in Cornwall, and at Nagyag in Transylvania, along with ores of tellurium, blende, copper-pyrites, compact red manganese, and brown-spar.

Genus II.—ZINC-BLENDE, or GARNET-BLENDE.

Granat-Blende, *Mohs.*

Many axes. Tessular. Streak brown and white. Hardness=3.5—4 0. Sp. gr=4.0—4 2.

1. Dodecahedral Zinc-Blende.—Dodecaedrischer Granat-Blende, *Mohs.* Blende, *Werner.*

Tessular. Cleavage dodecahedral. Streak white or reddish-brown.

External Characters.—Colours yellow, brown, and black. Occurs massive, disseminated, in granular concretions, and crystallized in rhomboidal dodecahedrons, octahedrons, and tetrahedrons. Lustre splendent and adamantine, inclining more or less to metallic. Alternates from opaque to transparent.

			Northumberland
Const. Parts.—Zinc,	. . .		58.8
Sulphur,	. . .		23.5
Iron,	. . .		8 4
Silica,	. . .		7.0—97.7
			Thomson.

Geognostic and Geographic Situations—It occurs in veins in primitive, transition, and floetz rocks, where it is generally associated with galena or lead-glance. Occurs in all the lead mines in Scotland and England, and also in those on the continent.

Uses.—It is principally valuable as an ore of Zinc.

Genus III.—ANTIMONY-BLENDE, or RED-BLENDE.

Nadel-Blende, *Mohs.*

Three axes. Prismatic. Streak red. Hardness=1.0—1.5. Sp. gr.=4.5—4.6.

1. Prismatic Antimony-Blende, or Red Antimony, *Jameson.*—Prismatische Nadel-Blende, *Mohs.*—Rothspiesglas-erz, *Werner.*

Prismatic. Pyramid unknown. Cleavage prismatoidal. Streak red.

External Characters.—Colour cherry-red. Occurs massive, disseminated, in flakes; in scopiform and stellular, fibrous, and granular distinct concretions; and crystallized in oblique four-sided prisms. Externally and internally shining. Lustre nearly adamantine. Opaque, or translucent on the edges. Colour not changed in the streak.

Const. Parts.—From the mine called Neue Hoffnung Gottes at Brünsdorf:

Antimony,	. . . .	67.50
Oxygen,	. . . .	10.80
Sulphur,	. . . .	19.70—98.00

Klaproth. Beit. b. iii. s. 182.

Geognostic and Geographic Situations.—This rare mineral occurs in veins, in primitive rocks, in Saxony, France, and Hungary.

Genus IV.—RUBY-BLENDE.

Rubin-Blende, *Mohs.*

One axis. Rhomboidal. Hardness=2.0—2.5. Sp. gr.=5.2—8.2.

Two species. viz. Rhomboidal and Prismato-Rhomboidal *Red Zinc.

1. Rhomboidal Ruby-Blende, or Red Silver, *Jameson.*—Rhomboedrische Rubin-Blende, *Mohs.*

Rhomboidal. Rhomboid=109° 28′. Cleavage rhomboidal. Streak red. Hardness=2.5. Sp. gr.=5.2.—5.8

External Characters.—Colour intermediate between cochineal-red and dark lead-grey, and sometimes inclines to carmine-red. Occurs massive, disseminated, in membranes; and crystallized in six-sided prisms, and six-sided pyramids. Externally alternates from shining to splendent; lustre semi-metallic or adamantine. Internally alternates from shining to glimmering; lustre sometimes adamantine, sometimes semi-metallic. Fracture uneven or conchoidal. Opaque, or more or less translucent. Streak cochineal-red.

Const. Parts.—	Silver,	. . .	60.0
	Antimony,	. .	20.3
	Sulphur,	. .	14.7
	Oxygen,	. .	5.0—100.0

Klaproth. Beit. b. v. s. 200.

Geognostic and Geographic Situations.—It occurs in veins in gneiss, mica-slate, porphyry, and grey-wacke, in various mining districts, as Cornwall, Hartz, Hungary, Mexico, and Peru

2. Prismato-Rhomboidal Ruby-Blende, or Cinnabar, *Jameson.*—Prismato-Rhomboedrische Rubin-Blende, *Mohs.*

Rhomboidal. Rhomboid about 8° 5′. Cleavage in direction of lateral planes of six-sided prism. Streak red. Hardness =2.0.—2.5. Sp. gr. 6.7.—8.2.

Is divided into two subspecies, viz. Common and Hepatic Cinnabar.

First Subspecies.

Common Cinnabar, *Jameson.*

External Characters.—Colours cochineal-red, scarlet-red, and carmine-red. Besides massive, disseminated, dendritic, and in granular concretions; it also occurs crystallized in six-sided prisms. Internally alternates from shining to glimmering; lustre adamantine, verging on semi-metallic. Fracture fine-grained uneven, even conchoidal, and earthy. Alternates from opaque to transparent. Yields a scarlet-red shining streak.

			Japan.
Constit. Parts.	Mercury,	.	84.50
	Sulphur,	.	14.75——99.25

Klaproth. Beit. b. iv. s. 17—19.

Geognostic and Geographic Situations.—It occurs most abundantly in the coal formation, and less plentifully in beds and veins in primitive rocks. There are considerable mines of this mineral at Idria in Carniola, and in other parts of Europe; also in Asia and America.

Uses.—It is from this mineral that most of the mercury of commerce is obtained.

Second Subspecies.

Hepatic Cinnabar, *Jameson.*—Quecksilber Lebererz, *Werner.*

External Characters.—Colour intermediate between dark cochineal-red and dark lead-grey. Occurs massive, disseminated, and in globular concretions. Internally alternates from glimmering to splendent. Lustre semi-metallic. Fracture even or slaty. Opaque.

Const. Parts.	Mercury	. .	81.80
	Sulphur,	. .	13 75
	Carbon,	. .	2.30
	Silica,	. . .	0.65
	Alumina,	. .	0.55
	Oxide of Iron,	.	0.20
	Copper,	. .	0.02
	Water,	. .	0.73——100

Klaproth, Beit. b. iv. s. 24.

Geognostic and Geographic Situations.—This mineral occurs in considerable masses in clay-slate and bituminous-shale, at Almaden in Spain, in Deux Ponts, and Siberia.

* Red Zinc, or Red Ore of Zinc, *Jameson.*—Red Oxide of Zinc. *Bruce.*

External Characters.—Colours blood-red and aurora-red. Occurs massive, and disseminated. Internally fresh fracture shining; after long exposure to the air it becomes dull, and even covered with a pearly crust. Cleavage undetermined. Fracture conchoidal. Translucent on the edges, or opaque. Easily scratched by the knife. Brittle. Affords a streak which is brownish-yellow, approaching to orange. Specific gravity 6.220.

Con. Parts.	Zinc,	. . . .	76
	Oxygen,	. . . .	16
	Oxides of Manganese and Iron,		8—100

Bruce, American Min. Jour. p. 99.

Geognostic and Geographic Situations.—This mineral has been hitherto found only in North America, where it occurs in several of the iron-mines in Sussex county, New Jersey; as at the Franklin, Sterling, and Rutgers mines, and near Sparta. In some instances it is imbedded in foliated granular limestone; while in others, it serves as a basis in which magnetic ironstone occurs, either in crystals or grains. At Franklin, it also assumes a micaceous form, and is imbedded in a whitish oxide of zinc, which is often, in the same specimen, found adhering to the black oxide of iron.

Uses.—This ore occurs abundantly in the United States of America, and promises to be a valuable acquisition to that country.

Order XIII. SULPHUR.

Schwefel, *Mohs.*

Three axes. Prismatic. Hardness =1.5.—2.5. Sp. gr. =1.9.—3.6.

Genus I.

1. Red Orpiment, or Ruby Sulphur, or Hemi-Prismatic Sulphur, *Jameson.*—Hemi-prismatisches Schwefel, *Mohs.* Rothes Rauschgelb, *Werner.*

Prism 107° 42′. Cleavage in the direction of the diagonals of the prism, but not perfect. Streak orange-yellow and aurora-red. Hardness =1.5.—2.0. Sp. gr. =3 3.—3 4.

External Characters.—Colour aurora-red. Occurs massive, disseminated, in flakes or membranes, and crystallized in oblique four-sided prisms, variously modified by acuminations, truncations, and bevelments. Internally shining. Lustre resinous, inclining to adamantine. Fracture uneven, sometimes passing into conchoidal. Translucent; crystals semi-transparent. Yields an orange-yellow coloured streak.

			Bannat.
Constit. Parts.	Arsenic	. .	69
	Sulphur,	. .	31——100

Klaproth, Beit. b. v. s. 238.

Geognostic and Geographic Situations.—It occurs most frequently in veins in primitive rocks, less frequently in secondary rocks. Different mining districts in Germany afford this mineral, and it is also a production of Japan, the north west coast of America, and of volcanoes.

Uses.—It is used as a pigment.

2. Yellow Orpiment, or Prismatoidal Sulphur, *Jameson.*—Prismatoidescher Schwefel, *Mohs.* Gelbes Rauschgeld, *Werner.*

Prismatic. Pyramid unknown. Cleavage prismatoidal. Streak lemon-yellow. Hardness =1.5.—2.0. Sp. gr. 3.4—3.6.

External Characters.—Colour lemon-yellow. Occurs massive, disseminated, stalactitic, reniform, botryoidal, in crusts, in granular and concentric curved lamellar concretions, and crystallized in oblique four-sided prisms, and in flat double four-sided pyramids. Splendent. Lustre intermediate between adamantine and semi-metallic. Translucent, but in small leaves transparent. Colour not altered in the streak. Sectile. Flexible, but not elastic.

			Turkey.
Constit. Parts.	Arsenic,	. .	62
	Sulphur,	. .	38——100

Klaproth, Beit. b. v. s. 238.

Geognostic and Geographic Situations. It occurs in veins in secondary and primitive rocks in Germany, Hungary, China, Mexico, and the United States.

3. Prismatic Sulphur, *Jameson.*—Prismatischer Schwefel, *Mohs.* Natürlicher Schwefel, *Werner.*

Prismatic. Pyramid =107° 19′; 84° 24′; 143° 8′. Cleavage pyramidal, and in the direction of prism 102° 41′. Streak white or sulphur-yellow. Hardness =1.5—2.5. Sp. gr. 1.9.—2.1.

First Subspecies.

Common Sulphur, *Jameson.*—Gemeiner Naturlicher Schwefel, *Werner.*

External Characters.—Colour yellow. Occurs massive, disseminated, in granular concretions, and crystallized in acute double six-sided pyramids. Internally varies from shining to glimmering. Lustre intermediate between adamantine and resinous. Fracture uneven. Translucent. Crystals semi-transparent and transparent, and refract double. Brittle, and easily frangible.

Chemical Characters.—It is easily inflammable, burning with a lambent bluish flame, and a suffocating odour.

Geognostic and Geographic Situations.—Common sulphur occurs in considerable abundance in primitive mountains, in a state of combination with metals; but rarely pure or uncombined; while in secondary mountains, it is more abundant in the pure uncombined state than in combination with metals. It is also met with in alluvial districts, particularly near sulphureous springs. It abounds in Iceland, Spain, Italy, &c.

Second Subspecies.

Volcanic Sulphur, *Jameson.*—Vulcanischer Natürlicher Schwefel, *Werner.*

External Characters.—Colour pale sulphur-yellow. Occurs massive, stalactitic, vesicular, corroded, perforated; crystallized in pyramidal figures. Glistening. Lustre resinous, inclining to adamantine. Fracture uneven. Translucent. In other characters it agrees with the preceding subspecies.

Geognostic and Geographic Situations.—It occurs only in volcanic countries, where it is found more or less abundantly among lavas. Solfatara, in the vicinity of Vesuvius, is one of the most famous repositories of volcanic sulphur, and it is there collected in considerable quantities for the purposes of commerce.

Uses.—When burnt, it affords sulphuric acid; it enters into the composition of gunpowder; is used in various metallurgic processes, and in bleaching; it forms a constituent part of some cements; is employed in taking casts; and is an article in the materia medica.

CLASS III.

If liquid, bituminous smell. If solid, tasteless. Specific gravity under 1.8.

Order I.—RESIN.

Liquid. Solid. Streak white, yellow, brown, black. Hardness =0—2.5. Sp. gr. =0.7—1.6. If 1.2, and more, the streak is white.

Genus. I. HONEYSTONE.

Crystal-Harz, *Mohs.*

Pyramidal. Hardness =2.—25. Sp. gr. =1.4—1.6.

1. Pyramidal Honeystone, *Jameson.*—Pyramidales Crystal-Harz, *Mohs.* Honigstein, *Werner.*

Pyramidal. Pyramid =118° 4'.--93° 22'. Cleavage pyramidal and imperfect.

External Characters.—Colour yellow. Rarely massive. Generally crystallized in flat double four-sided pyramids. Lustre shining or splendent. Fracture conchoidal. Semi-transparent, or translucent, and refracts double.

Constituent Parts.	Alumina,	16
	Mellilitic Acid,	46
	Water of Crystallization,	38--100

Klaproth, Beit. b. iii. s. 114.

Geognostic and Geographic Situations.—It occurs superimposed on bituminous wood and earth-coal, and is usually accompanied with sulphur. It has been hitherto found only at Artern in Thuringia.

Genus II.--MINERAL RESIN.

Erd-Harz, *Mohs.*

Amorphous. Hardness =0—2.2. Sp. gr.=0.8—1.2.

This genus contains two species, viz. Yellow Mineral Resin, and Black Mineral Resin.

1. Yellow Mineral Resin, or Amber, *Jameson.*—Gelbes Erdharz, *Mohs.*

Solid. Yellow. White. Streak White. Hardness =2.0--2.5. Sp. gr. =1.0--1.1.

External Characters.—Colours yellow and white. Occurs in massive pieces, disseminated, and often incloses insects. Externally dull; internally splendent, shining or glistening, and lustre resinous. Fracture conchoidal. Transparent or translucent.

Chemical Characters.—It burns with a yellow-coloured flame, and fragrant odour, at the same time intumescing, but scarcely melting.

Physical Characters.—When rubbed, it gives out an agreeable smell, and becomes strongly resino-electric. This latter property was known to the ancients, who termed amber *electrum;* from whence is derived the word *electricity.*

Constituent Parts.—It is composed of carbon, hydrogen, and oxygen. An acid named *Succinic* is obtained from it by distillation.

Geognostic and Geographic Situations.—It occurs in beds of bituminous wood and moor coal; also in a conglomerate formed by the aggregation of fragments on sea-shores; in sandy soil; frequently floating on the sea; and it is said to have been observed imbedded in secondary limestone. It is found on the shores of Scotland and England, of the Baltic, and in Germany, Poland, and other countries.

Uses.—On account of its beautiful colour, great transparency, and the fine polish it receives, it is considered as an ornamental stone, and is cut into necklaces, bracelets, snuff-boxes, and other articles of dress.

2. Black Mineral Resin, *Jameson.* Schwarzes, Erd-Harz, *Mohs.*

Solid, liquid. Black, brown, red, grey. Streak black, brown, yellow, grey. Hardness =0.2. Sp. gr. =0.8—1.2.

This species is divided into three subspecies, viz. Naphtha, Mineral Oil or Petroleum, and Mineral Pitch or Bitumen.

First Subspecies.

Naphtha, *Jameson.*

External Characters.—Colours yellowish-white, yellowish-grey, and wine-yellow. Perfectly liquid. Shining and resinous. Feels greasy. Exhales an agreeable bituminous smell.

Chemical Characters.—Takes fire on the approach of flame, affording a bright white light.

Constituent Parts.—Is a compound of carbon, hydrogen, and a little oxygen.

Geognostic and Geographic Situations.—This mineral is seldom found in a pure state. It is said to occur in considerable springs on the shores of the Caspian Sea, in the Caucasus, and other places.

Uses.—In Persia, Japan, and some parts of Italy, where it occurs in considerable quantity, it is used in lamps, in place of oil, for lighting streets, churches, &c.

Second Subspecies.

Mineral Oil, or Petroleum, *Jameson.* Erdöl, *Werner.*

External Characters.—Colour dark blackish brown, which sometimes inclines to green. Liquid, but approaches more or less to the viscid state. Shining and resinous. Feels greasy. Semi-transparent, translucent, and opaque. Exhales a strong bituminous odour.

Geognostic and Geographic Situations.—It generally flows from rocks of the coal formation, and usually from the immediate vicinity of beds of coal; also from limestone rocks. It occurs in marshes, on the surface of spring water; or it flows or trickles unmixed from its mineral repository. Is found at St. Catherine's well, near Edinburgh, in the Orkney Islands, in Shropshire in England, &c.

Uses.—In Piedmont, Persia, Japan, and other countries, it is used in lamps in place of oil, for lighting streets and churches.

Third Subspecies.

Mineral Pitch, or Bitumen, *Jameson.*

This species is divided into three kinds, viz. Earthy Mineral Pitch, Slaggy Mineral Pitch, and Elastic Mineral Pitch.

First Kind.—Earthy Mineral Pitch, *Jameson.*—Erdiges Erdpech, *Werner.*

External Characters.—Colour blackish brown. Occurs massive. Faintly glimmering, inclining to dull. Fracture earthy or uneven. Streak shining and resinous. Soft. Sectile. Feels greasy.

Geognostic and Geographic Situations.—It occurs in the Iberg in the Hartz, along with slaggy mineral pitch, in veins that traverse grey wacke; also in other places.

Second Kind.—Slaggy Mineral Pitch, or Asphaltum, *Jameson.*—Schlackiges Erdpech, *Werner.*

External Characters.—Colour pitch black. Occurs massive, disseminated, sometimes globular, reniform, and stalactitic. Externally and internally splendent and shining, and lustre resinous. Fracture conchoidal. Soft. Opaque. Sectile.

Geognostic and Geographic Situations.—It occurs in veins in reniform and imbedded masses in secondary limestone in Fifeshire; in clay ironstone in East Lothian; in veins at Haughmond Hill in Shropshire, and in mineral veins in Cornwall.

Uses.—The Egyptians employed it in the process of embalming bodies. The Turks quarry it in Albania, and use it, when mixed with common rosin, for paying the bottoms of ships, and for smearing the rigging.

Third Kind.—Elastic Mineral Pitch, *Jameson.*—Elastiches Erdpech, *Werner.*

External Characters.—Colour brown. Occurs massive, reniform, and sometimes with impressions. Internally shining and glistening, and lustre resinous. Fracture curved slaty, or conchoidal. Translucent on the edges. Shining in the streak. Perfectly sectile. Elastic flexible.

Geognostic and Geographic Situations.—It is found in the cavities of a lead glance vein in the lead mine called Odin, which is situated near the base of Mamtor, to the north of Castletown in Derbyshire.

Order II.—COAL.

Solid. Streak brown and black. Hardness = 0.1—2.5. Sp. gr. = 1.2—1.5.

Genus I.—COAL.

Amorphous. Hardness = 1.—2.5. Sp. gr. = 1.2—1.5.

This genus contains two species, viz. Bituminous Coal, and Glance Coal.

1. Bituminous Coal, *Jameson.*—Harzige Kohle, *Mohs.*

Colours black and brown. Resinous lustre. Bituminous smell. Hardness = 1.—2.5. Sp. gr. = 1.2—1.5.

This species contains two subspecies, viz. Brown Bituminous Coal, and Black Bituminous Coal.

First Subspecies.

Brown Bituminous Coal, or Brown Coal, *Jameson.* Braun Kohle, *Werner.*

This subspecies is divided into five kinds, viz. 1. Bituminous Wood, or Fibrous Brown Coal. 2. Earthy Coal, or Earthy Brown Coal. 3. Alum Earth. 4. Common Brown Coal, or Conchoidal Brown Coal; and, 5. Moor Coal, or Trapezoidal Coal.

First Kind.—Bituminous Wood, or Fibrous Brown Coal, *Jameson.*—Bituminoses Holz, *Werner.*

External Characters.—Colour brown. External shape resembles exactly that of stems and branches of trees, but usually compressed. Principal fracture glimmering or glistening; cross fracture shining. Fracture fibrous in the small, slaty in the great. Opaque. Streak shining.

Geognostic and Geographic Situations.—Occurs in alluvial land, or in secondary rocks; and is found in Scotland, England, Ireland, &c.

Second Kind.—Earth-Coal, or Earthy-Brown Coal, *Jameson.*—Erdkohle, *Werner.*

External Characters. Colours brown and grey. Occurs massive. Its consistence is between cohering and loose, but more inclined to the latter. Particles coarse, dusty, and soil a little. Internally faintly glimmering, passing into dull. Fracture in the more cohering masses fine earthy. Streak somewhat shining.

Geognostic and Geographic Situations.—Is found, along with bituminous wood, in Thuringia, and other countries.

Uses.—It is used as fuel where no great degree of heat is required, as in heating rooms, salt, nitre, and alum works, and in distillation.

Third Kind.—Alum Earth, *Jameson.*—Alaunerde, *Werner.*

External Characters.—Colour black. Massive. Dull, sometimes glimmering; but this is owing to an intermixture of mica. Fracture in the great, thick or thin slaty; in the small, earthy. Breaks into tabular pieces. Streak shining. Is sectile, and uncommonly easily frangible.

Geognostic and Geographic Situations.—It occurs in alluvial districts in France, Germany, Italy, and Hungary.

Uses.—It is first exposed to the air for several months, and then lixiviated, to obtain the alum it contains; it is rarely used for fuel.

Fourth Kind.—Common Brown Coal, or Conchoidal Brown Coal, *Jameson.*—Gemeine Braunkohle, *Werner.*

External Characters.—Colour Black. Occurs massive, and sometimes ligniform. Internally shining, sometimes glistening, and lustre resinous. Fracture conchoidal, and sometimes shows the fibrous woody texture. Colour lighter in the streak.

Constituent Parts.—200 grains of the Bovey brown coal, by distillation, yielded,

1. Water, which soon came over acid, and afterwards turbid, by the mixture of some bitumen	60 grains
2. Thick brown oily bitumen, . .	21
3. Charcoal	90
4. Mixed gas, consisting of hydrogen, carbonated hydrogen, and carbonic acid .	29—200

Hatchett, *Phil. Trans.* 1804.

Geognostic and Geographic Situations.—It occurs in alluvial land, and in secondary or floetz-trap rocks, in England, Ireland, France, &c.

Use.—It is used as fuel.

Fifth Kind.—Moor Coal, or Trapezoidal Brown Coal, *Jameson.*—Moorkohle, *Werner.*

External Characters.—Colours brown and black. Occurs massive, when first dug, but soon bursts and splits into rhomboidal pieces. Lustre of the principal fracture glimmering, of the cross fracture glistening, and lustre resinous. Principal fracture imperfect slaty; the cross fracture even approaching to conchoidal. Sectile. Streak shining. Uncommonly easily frangible. The most frangible species of coal.

Geognostic and Geographic Situations.—It occurs in great beds in alluvial lands, and in floetz trap rocks in Bohemia, Germany, &c.

Second Subspecies.

Black Bituminous Coal, *Jameson.*—Schwartzkohle, *Werner.*

This subspecies is divided into four kinds, viz. Slate Coal, Cannel Coal, Foliated Coal, and Coarse Coal.

First Kind.—Slate Coal, *Jameson.*—Schieferkohle, *Werner.*

External Characters.—Colour black. Occurs massive. Shining or glistening, and lustre resinous. Principal fracture nearly straight, and generally thick slaty; cross fracture imperfect and flat conchoidal, and sometimes even or uneven. Lustre increased in the streak.

Geognostic and Geographic Situations.—Abounds in all the coal districts in Great Britain.

Second Kind.—Cannel Coal, *Jameson.*—Kennelkohle, *Werner.*

External Characters.—Colour black. Massive. Internally glistening or glimmering, and lustre resinous. Fracture large and flat conchoidal, or even.

Geognostic and Geographic Situations.—It occurs, along with the preceding subspecies, in the coal formation in most of the coal fields of Great Britain.

Uses.—On account of its solidity, and the good polish it is capable of receiving when pure, it is cut into drinking vessels of various kinds, inkholders, snuff-boxes, &c.; but its principal use is as fuel.

Third Kind.—FOLIATED COAL, *Jameson.*—Blätterkohle, *Werner.*

External Characters.—Colour velvet black. Massive, and in lamellar concretions. Lustre splendent and resinous. Fracture uneven. Softer than cannel coal.

Geognostic and Geographic Situations.—It occurs in the coal formation, although not abundantly, and generally accompanied with slate coal, in Saxony and Silesia.

Fourth Kind.—COARSE COAL, *Jameson.*—Grobkhole, *Werner.*

External Characters.—Colour black. Massive, and in granular concretions, which are intimately aggregated together. Glistening and resinous. Principal fracture imperfect, and thick scaly; cross fracture fine-grained uneven.

Geognostic Situation.—Occurs in the coal formation in Germany.

2. GLANCE COAL, *Jameson.*—Harzlose Steinkohle, *Mohs.*

Colour black. Imperfect metallic lustre. No bituminous smell. Hardness = 2.—2.5. Sp. gr. = 1.3—1.5.

This species contains two subspecies, viz. Pitch Coal, and Glance Coal.

FIRST SUBSPECIES.

PITCH COAL, or JET, *Jameson.*—Pechkohle, *Werner.*

External Characters.—Colour velvet black. Occurs massive; and it is said also in plates, and sometimes in the shape of branches, with a regular woody internal structure. Internally splendent, and the lustre resinous, inclining to metallic. Fracture large and perfect conchoidal. Affords a brown coloured streak.

Chemical Characters.—It burns with a greenish flame. Its chemical constitution is still imperfectly understood.

Geognostic and Geographic Situations.—It occurs along with brown coal, in beds in flœtz trap and limestone rocks; also in beds and in imbedded portions in bituminous shale, in Scotland, Faroe Islands, and Germany.

SECOND SUBSPECIES.

GLANCE COAL, *Jameson.*—Glanzkohle, *Werner.*

This subspecies contains four kinds, viz. 1. Conchoidal, 2. Slaty, 3. Columnar, 4. Fibrous.

First Kind.—CONCHOIDAL GLANCE COAL, *Jameson.*—Muschliche Glanzkohle, *Werner.*—Anthracite Compacte, *Hauy.*

External Characters.—Colour iron black. Massive and vesicular. Internally splendent and shining, and lustre imperfect metallic. Fracture conchoidal.

Chemical Characters.—It burns without flame or smell, and leaves a white coloured ash.

Geognostic Situation.—It occurs in beds in transition and secondary rocks.

Geographic Situation.—It occurs in beds in the coal formation of Ayrshire, as near Cumnock and Kilmarnock; in the coal districts in the river district of the Forth; and in Staffordshire in England.

Second Kind.—SLATY GLANCE COAL, *Jameson.*—Schiefvige Glanzkohle, *Werner.*—Anthracite feuilleté, *Hauy.*

External Characters.—Colour dark iron black, seldom inclining to brown; those varieties that border on graphite incline to steel grey. Massive. Internally shining and glistening, and lustre imperfect metallic. Principal fracture slaty; cross fracture conchoidal or uneven.

		Panzenberg.	Dolomieu.
Constituent Parts.—	Carbon	90	72.05
	Silica	4 to 2	13.19
	Alumina	4 to 5	3.29
	Oxide of iron	2 to 3	3.47
	Loss .		8.00
		100	100.00

Geognostic and Geographic Situations.—It occurs in imbedded masses, beds and veins, in primitive transition, and secondary rocks. It is found in sandstone in Arran; in trap-rocks in the Calton Hill at Edinburgh; and in the coal formation in the river district of the Forth.

Observation.—In this country it is named Blind Coal.

Third Kind.—COLUMNAR GLANCE COAL, *Jameson.*—Stangenkohle, *Voigt.*—Houille bacillaire, *Hauy.*

External Characters.—Colour black. Occurs massive, disseminated; also in prismatic concretions. Lustre shining and glistening, and imperfect metallic. Fracture conchoidal or uneven.

Chemical Characters.—It burns without flame or smoke.

Geognostic and Geographic Situations.—It forms a bed several feet thick, in the coal field of Sanquhar in Dumfries-shire, and occurs in other parts of Scotland.

Fourth Kind.—FIBROUS COAL, or MINERAL CHARCOAL, *Jameson.*—Mineralische Holzkohle, *Werner.*

External Characters.—Colour black. Massive, in thin layers, and single pieces; also in fibrous distinct concretions. Is glimmering, bordering on glistening, and lustre silky or pearly. Soils strongly. Soft, passing into friable. Very easily frangible.

Chemical Characters.—When exposed to a strong heat, it burns without flame or smoke; some varieties scarcely yield to the most intense heat.

Geognostic and Geographic Situations.—It occurs imbedded, or in thin layers, in black coal, sometimes enclosed in pitchstone, and it is said also occasionally associated with some varieties of brown coal. It is met with in the different coal fields of Great Britain, and in similar situations on the continent of Europe.

APPENDIX.

Minerals whose Characters and place in the System have not been determined.

MINERALS of First and Second Classes.

1. ALLOPHANE, *Stromeyer.*

External Characters.—Principal colour blue; also occurs green and brown. Occurs massive, disseminated, small reniform, and botryoidal. Externally and internally shining or glistening, and lustre vitreous. Fracture conchoidal. Transparent, but only translucent on the edges in the brown varieties; semi hard; brittle, and uncommonly easily frangible. Specific gravity 1.852 to 1.889, *Stromeyer.*

Chemical Characters.—It readily gelatinates in acids.

Constit. Parts.—	Water,	41.301
	Silica,	21.922
	Alumina,	32.202
	Lime,	0.730
	Sulphate of Lime,	0.517
	Carbonate of Copper,	3.058
	Hydrate of Iron,	0.270—100
		Stromeyer.

Geognostic and Geographic Situations.—Occurs in a bed of ironshot limestone in grey-wacke slate in the forest of Thuringia.

2. AMBLYGONITE, *Breithaupt.*

External Characters.—Its colours are greenish-white, pale-mountain-green, and celandine-green, and marked externally with reddish and yellowish-brown spots. Occurs massive; and crystallized in oblique four-sided prisms; internally shining and vitreous. Cleavage said to be parallel with the sides of an oblique four-sided prism of 186° 10′ and 73° 50′. The fracture uneven. Ranges from translucent to translucent on the edges; as hard as felspar; brittle, and easily frangible. Specific gravity 3.00, 3.04, *Breithaupt.*

Geognostic and Geographic Situations.—It occurs in granite, along with green topaz and tourmaline, near Penig in Saxony.

3. APLOME, *Hauy.*

This mineral has a deep brown or orange-yellow colour. Occurs crystallized in rhomboidal dodecahedrons, which are so streaked as to point out a hexahedral cleavage. In lustre, fracture, and hardness, it agrees with common garnet, but its specific gravity is lower, not exceeding 3.444. It is found on the banks of the river Lena in Siberia.

4. CRICHTONITE, *Jameson.*—Craitonite, *Bournon.*

External Characters.—Colour velvet-black. Occurs crystallized in very acute rhomboids, with angles of 18° and 162°. Externally and internally splendent, and lustre vitreous, inclining to metallic. Cleavage imperfect. Fracture conchoidal. Opaque. Harder than octahedrite. Scratches fluor-spar, but does not affect glass. Sp. gr. =3.0.

Chemical Character.—It is infusible without addition before the blowpipe.

Constit Parts.—Zirconia, 46; Silica, 33; Alumina, 14; Iron, 4; Manganese, 1; Loss, 2 =100.

Geognostic Situation.—It occurs in primitive rocks, along with octahedrite, in the districts where that mineral is found.

5. FIBROLITE, *Bournon.*

External Characters.—Colours white and grey. Occurs in fibrous concretions, and in oblique prisms of =100°. Internally glistening. Harder than quartz. Sp. gr. =3.214.

Geographic Situation.—It is found in the Carnatic.

6. GEHLENITE, *Jameson.*

This mineral, named in honour of the late Gehlen, has not been accurately described. It is said to have a green or grey colour; to occur crystallized in rectangular four-sided prisms, and therefore must belong either to the pyramidal or prismatic series; it is nearly as hard as felspar, and the specific gravity=2.9—3.1.

Geognostic and Geographic Situations.—Occurs along with calcareous-spar in the valley of Fassa in the Tyrol.

7. LIEVRITE, *Jameson.*—Jenite, *Hauy.*

External Characters.—Colour black, and blackish-green. Occurs massive; also in distinct concretions, which are small and scopiform radiated, and in others which are thin and straight prismatic; and crystallized in oblique four-sided prisms, variously modified by acuminations and bevelments. Lustre of the fracture glistening and semi-metallic. Fracture uneven. Opaque. Nearly as hard as felspar. Does not change its colour in the streak. Specific gravity 3.825, 4.061, *Lelievre.*

Const. Parts.—	Silica,	30.0
	Alumina,	1.0
	Lime,	14.8
	Oxide of Iron,	49.0
	Oxide of Manganese	2.0—96.8. *Vauq.*

Geognostic and Geographic Situations.—Occurs in primitive limestone, along with epidote, quartz, garnet, magnetic ironstone, and crystallized arsenic pyrites, at Rio la Marine, and Cape Calamite, in the island of Elba. Said also to occur in Siberia.

8. SPHAERULITE, *Breithaupt.*

External Characters.—Colours brown and grey. Occurs in imbedded roundish balls and grains, which are sometimes reniformly aggregated; also in stellular fibrous concretions. Externally smooth, (when it has a milky incrustation,) sometimes rough. Internally alternates from glimmering to dull. Fracture even and splintery. Opaque, or translucent on the edges. Scratches quartz with difficulty. Specific gravity 2.52.

Chem. Char.—Nearly infusible before the blowpipe.

Geognostic and Geographic Situations.—Occurs in pearlstone and pitchstone-porphyries, where it is often associated with small scales of mica, and portions of felspar, in Arran, Saxony, Hungary, and Iceland.

9. SKORODITE, *Breithaupt.*

External Characters.—Colours green and brown. Occurs massive and disseminated, but most frequently crystallised, in very short broad rectangular four-sided prisms, acutely acuminated on both extremities, with four planes, which are set on the lateral edges. There in one distinct cleavage parallel with the broader lateral planes of the prism, consequently in the direction of the shorter diagonal of an oblique four-sided prism. Fracture intermediate between uneven and conchoidal. Translucent on the edges, or semi-transparent. As hard as calcareous-spar, but not so hard as fluor-spar. Sp. gr. =3.3.

Chemical Characters.—It easily melts before the blowpipe, with the copious emission of arsenical vapour, and is converted into a reddish-brown mass, which, when highly heated, so as to drive off all the arsenic, becomes attractable by the magnet. These phenomena shew that this mineral is an arseniate of iron, probably combined with manganese. It contains no copper.

Geognostic and Geographic Situations.—Occurs imbedded in a bed composed of quartz and hornstone, in primitive rocks in the Schneeberg mining district in Saxony; also at Loling in Carinthia.

10. Spak, *Jameson and Breithaupt.*

External Characters.—Colour white. Occurs in small veins, and in thin prismatic distinct concretions. Internally shining and resinous. Has a threefold rectangular cleavage. Fracture small-grained uneven, also small splintery. Translucent. Soft, inclining to very soft. Brittle, and easily frangible. Has a feeble sweetish saline taste.

Chem. Characters.—It is completely soluble in water.

Geognostic and Geographic Situations.—Occurs in the salt-mines of Wielickzka and Bochnia in Poland.

Observations.—1. Its taste is very different from that of common salt, and therefore cannot, like that mineral, be used with food. 2. It is said to be the fibrous rock-salt of Werner.

11. Spinellane, *Hauy.*

External Characters.—Colour plum-blue. Occurs crystallized, in rhomboids of 117° 23′, and 62° 37′; and in six-sided prisms acuminated with three planes. Scratches glass.

Geognostic and Geographic Situations.—Occurs on the shores of the Lake of Laach, in a rock composed of grains and small crystals of glassy felspar, quartz, hornblende, black mica, and magnetic iron-ore.

12. Blue Ironstone, *Klaproth.*

External Characters.—Colour indigo-blue. Occurs massive, and with impressions of crystals of brown iron-ore. Externally glimmering, internally dull. Fracture coarse-grained uneven. Opaque. Semihard. Rather brittle, and easily frangible. Specific gravity 3.20, *Klaproth.*

Chemical Characters.—Loses colour on exposure to heat, and when melted with borax, forms a clear green bead.

Constit. Parts.—	Oxide of Iron,	40.5
	Silica,	50.0
	Lime,	1.5
	Natron,	6.0
	Water,	3.0—100.0

Geographic Situation.—It occurs on the Orange River in Southern Africa.

Uses.—It is used for painting houses at the Cape of Good Hope.

* Chusite, Limbillite, Siderocleptc, Mellilite, and Succinite, minerals described by Saussure and Bonvoisin, appear to be varieties of Olivine and Augite.

MINERALS OF THIRD CLASS.

13. Argentiferous Copper Glance, *Jameson.*—Silber Kuperler-glanz, *Hausmann.*

External Characters.—Colour blackish lead-grey. Occurs massive and disseminated. Internally shining or glistening, and lustre metallic. Fracture flat conchoidal, passing into even. It becomes more shining in the streak, but the colour is not changed. As hard as calc-spar. Sectile, and rather difficultly frangible. Specific gravity 6.255, *Stromeyer.*

Constit. Parts.—	Sulphuret of Copper,	38.654
	Sulphuret of Silver,	60.646
	Sulphuret of Iron,	0.700—100
		Stromeyer.

Geognostic and Geographic Situations.—This rare mineral is found only at Schlangenberg in Siberia, where it is associated with copper-pyrites, calcareous-spar, and hornstone.

14. Bismuthic Silver, *Jameson.*

External Characters.—Colours pale lead-grey, becoming deeper on exposure to the air. Occurs disseminated; and rarely crystallized in acicular and capillary crystals. Lustre glistening and metallic. Fracture fine-grained uneven. Soft. Sectile.

Constit. Parts.—	Bismuth,	27.00
	Lead,	33.00
	Silver,	15.00
	Iron,	4.30
	Copper,	0.90
	Sulphur,	16.30—96.50.
		Klaproth, Beit. b. ii. s. 297.

Geognostic and Geographic Situations.—It has hitherto been found only in the mine named Friedrich-Christian in the Schapbach, in the Black Forest, where it occurs in veins that traverse gneiss, along with copper-pyrites, quartz, iron-pyrites, and galena or lead-glance.

15. Native Nickel, *Jameson.*—Haarkies, *Werner.* Nickel Natif, *Hauy.*

Observation.—It is the *Haarkies* of Werner.

External Characters.—Colour kind of brass-yellow, which inclines to bronze-yellow, and seldomer to steel-grey. Occurs in delicate capillary crystals. Shining or glistening, and lustre metallic. Crystals rigid. Brittle.

Const. Parts.—It consists, according to Klaproth, of Nickel, with a small quantity of cobalt and arsenic.

Geognostic and Geographic Situations.—It occurs in veins in gneiss, where it is associated with hornstone, quartz, calcareous-spar, and brown-spar, at Johangeorgenstadt in Saxony; also in the cavities of copper nickel in Huel Chance Mine, near St. Austle in Cornwall.

16. Pyrosmalite, *Jameson.*

External Characters.—Colour liver-brown, inclining to pistachio-green. Occurs in straight lamellar concretions, and crystallized in regular six-sided prisms. The most distinct cleavage is parallel with the terminal planes of the prism; another, less distinct, parallel with the lateral planes of the prism. Fracture uneven, passing into splintery. Internally lustre of cleavage shining and pearly. Fracture glimmering. Translucent on the edges. Semi-hard. Streak brownish-white. Brittle. Specific gravity, 3.081.

Constit. Parts.—	Protoxide of Iron,	21.810
	Protoxide of Manganese,	21.140
	Submuriate of Iron,	14.095
	Silica,	35.850
	Lime,	1.210
	Water, and Loss,	5.895—
		Hisinger.

Geognostic and Geographic Situations.—It occurs in a bed of magnetic ironstone, along with calcareous-spar and hornblende, in Bjelke's mine in Nordmark, near Philipstadt in Wermeland.

INDEX.

MINERVA, in the ancient mythology, was the Goddess of Wisdom and the Liberal Arts. Jupiter having married Metis, is said to have decided that her children would be more intelligent than their father. Hence he was induced to murder her during pregnancy; and having afterwards suffered violent pains in his head, he ordered Vulcan to cleave it open, when Minerva emerged from Jupiter's brain, fully armed, and was immediately admitted among the gods. She was known by the names of Athena, Pallas, Parthenos, Tritonia, Glaucopis, Agorea, Hippia, Stratea, Area, Coryphagenes, and Sais.

This goddess was very universally worshipped. Sais, Rhodes, and Athens, paid her particular reverence; but she had magnificent temples in Egypt, Phœnicia, Italy, Gaul, Sicily, and all parts of Greece. Being considered as the goddess who introduced arts and inventions into the world, she was invoked by artists of all descriptions, and had a temple built for her by the Athenians under the name of Minerva Μηχανιτις, *machinatrix.*

Minerva is generally represented with a helmet, surmounted by a large plume. She carries a spear, and sometimes a distaff, in one hand, and with the other grasps a shield adorned with the head of the dying Medusa. The breastplate sometimes bore the Medusa's head encircled with living serpents. The owl, cock, and the dragon, were sacred to her. Her functions and actions are very numerous, and are familiar to all classical readers.

MINGRELIA, a province of Asia, comprehending the most considerable proportion of the ancient kingdom of Colchis. It is bounded on the north by the Ceraunian mountains and Circassia; on the south and east by Immertia, and the river Phasis; and on the west by the Black Sea. The air of this country is damp and insalubrious. It is watered by upwards of thirty rivers, the principal of which is the Phasis. The soil along the coast of the Black Sea is so moist, that it is incapable of bearing the operation of ploughing. It is impossible on this account to raise either wheat or barley, and the inhabitants use as a substitute for bread a kind of paste made of a small grain called gom, which is not unlike coriander seed. Agriculture is entirely neglected in this province, and the proportion of arable land is very small. The pasturage, however, is excellent, and a great number of horses are reared. The country abounds with extensive forests of the finest trees, and also with grapes, (from which they make admirable wine) and all sorts of fruits grow wild in great abundance. There was formerly a great number of gold mines in this country, but they are no longer wrought. The Mingrelians cultivate a good deal of silk, but from their ignorance of the art of manufacturing it, nothing is made but a poor sort of handkerchief, and some common taffeties. The principal commerce is in slaves, of which they annually export about 12,000. The peasants are the slaves of the nobility, who have the power of life and death over their vassals. The natives of Mingrelia, it is said, were originally descended from a colony of Egyptians, founded here by Semiramis. They were formerly an enlightened and industrious people, but they have now degenerated into a state of deplorable ignorance and misery. They are in general well-shaped and handsome, but addicted to drunkenness, theft, and many other vices. The principal cities of Mingrelia are Talikara, which is the most considerable, situated on the right bank of the river Hippus, and well peopled, principally by Jews;—Rhregia, also situated on the Hippus, and the usual place of residence of the chiefs or princes of Mingrelia; and Cotais, or Cotatis, which stands on the Phasis. It is a very poor and ancient town, situated in a beautiful and fertile plain, and inhabited by a few Jewish, Armenian, and Turkish families. The religion of the country is that of the Greek church. The population is said to be about four millions. See Kinneir's *Geog. Mem. of Persia.*

MINIATURE PAINTING. This term is usually applied to portraits painted on a very small scale, and commonly executed in water colours on ivory, sometimes on vellum or on paper. Miniatures are also sometimes executed in oil colours.

Although this department of art, from the reduced scale on which its operations are conducted, and the delicacy of handling necessarily resulting from this, is incapable of conveying so completely the grander expressions of character, so striking in the portraits of Titian and Vandyke, to which the larger dimensions, and consequent breadth of manner and vigour of style, so powerfully contribute; it nevertheless possesses many advantages from its portable dimensions, and is equally susceptible of fidelity of resemblance, and beauty of execution. As in reference to composition, design, *chiar'oscuro*, and colouring, it is regulated by the same general principles as the other departments of the art, (See PAINTING,) we shall restrict ourselves at present to the various processes and practical details, by which miniature painting is executed.

Ivory is the substance on which miniatures are most commonly executed, being greatly superior to paper, vellum, or any other material, and, in the hand of a skilful artist, is capable of giving all the depth, richness, and brilliancy of colour, and power of effect, of an oil picture. The ivory is obtained in the shops, sawn into thin plates: That which is clearest and most transparent is the best, receives the colours most readily, and bears better repeated touching.

The ivory is to be prepared by first removing from its surface the marks of the saw, by means of the scraper, an instrument (the same as that used by engravers) consisting of three sharp edges, of the form of a triangular or saw file. The ivory is then laid upon a flat piece of ground-glass, and dusted over with finely pulverized pumice stone, previously sifted through fine gauze; a little distilled vinegar is poured upon it, and the whole well rubbed with a glass *muller*. When this process has been continued for a few minutes, it is washed with clean water and dried; it is then well rubbed with dry pumice dust and a piece of chamois leather, and is fit for use; having been, by this operation, deprived of the gloss and fine polish communicated by the scraper. Some artists use only the pumice dust dry, without the distilled vinegar; but the latter seems to be of considerable importance in removing the grease, or other animal matters, which all ivory contains. In addition to the pumice dust, which is indispensable to give a proper surface to the ivory, some, in order to whiten it more completely, boil it along with fuller's earth, and others bleach it by exposure to the action of the sun's rays; but the process which we have first mentioned will in most cases answer every purpose that can be desired, both as to colour and surface, if the ivory be of a good quality.

When the ivory is fully prepared, it is fixed upon a piece of fine white card paper, by means of a spot or two of *gum Arabic*, and thus is obviated any disadvantage arising from the transparency of the ivory.

The outline is sketched out with a warm neutral tint, applied with a fine hair pencil. Some artists make use of a black lead pencil for this purpose; but, as it is much more easy to make corrections with the water colours, the former method is preferable. The whole face is washed over with a very delicate tint, according to the complexion required; as, for instance, in a dark complexion, a wash of light red; for a fair one, a wash of yellow ochre or vermillion. The half tints, and darker shadows, are to be made out, the former with a neutral tint, composed of lake, a small portion of Indian red, and a little blue, which form a reddish pearly hue, the latter with lake and Vandyke brown. The delicate shadows are to be made out in a broad and flat manner, and the deeper markings are to be added, rounding them delicately into the *neutral tint*, according to the effect on the model. This *neutral*, or *half-tint*, makes a good warm preparation for the more decided colours. Others compose a good neutral tint of *Indian red*, *indigo*, and *burnt terra di Sienna*. The general effect of the face being thus made out, the more positive colours, such as the reds of the cheek, and other fleshy tones, are to be introduced, and may be formed by a mixture of *light red* and a little *lake*. The yellows are to be strengthened where it may be judged necessary, and the face will now have received all its warm tints, which are to be harmonized by the judicious intermixture of the cold colours.

The hair, drapery, back-ground, and, in short, every part of the picture, ought to be brought forward at the same time as the face, in order to show the proper depth and strength of colour and *keeping* in every part. The local colour of the hair is laid in with broad flat tints, marking out only the larger masses and divisions with their shadows. The colours for the hair may be composed of *burnt umber*, *lake*, and *indigo*, in such proportions as may best imitate the tints of the model; for light hair Roman ochre may be used instead of burnt umber.

Some artists, in laying on the back grounds, *float* them, as it is called, with a full mass of the proper colour, perfectly transparent, leaving it in a horizontal position to dry before it be touched upon, and after retouching it with repeated hatching and stippling till it be brought up to the effect required; in this way it is extremely difficult to produce a smooth even tint. It is therefore much more convenient to add to the colours a little *constant white*, in order to give them a degree of opacity, by which the ivory will be more easily covered, the tint will be much smoother, and it will require much less labour in hatching it afterwards.

In all draperies, except thin white ones, it is necessary to add a considerable portion of opaque colour, in order to give the requisite solidity of effect. In lighter coloured draperies, *constant white* may be mixed with the colours, but in stuffs where great strength of colour is required, those pigments which are in themselves opaque, may be used, such as the ochres, vermillion, Indian red, umber, which all give body and consistency to any other colours. In dark grey, purple, and black, a little constant white will be most suitable. In representing thin white draperies, such as muslins, and the like, the opaque white must only be used in heightening the lights; the shadows may be done with transparent colours as delicately as possible, in order to assimilate the style of handling as much as possible to the quality of surface of the object.

The draperies and back-grounds should be laid on in full masses, with a large hair pencil, crossing and working the colour in every direction; and if it be sufficiently opaque, it will cover the surface of the ivory without much retouching. The lights are to be composed of the proper colour, thickened with *constant white*.

The general effect of the whole work being made out according to the rules now given, it will be necessary to carry on the several details through all their stages in the same manner.

In bringing the face to its proper strength of shadow and colour, the warm tints ought in general to predominate; it will require however various cool tints to be introduced, in order to give brilliancy to the lights, and clearness to the shadows; these tints must be regulated by the taste of the artist, but in general it may be recommended to use purple and olive tints, the former composed of carmine and indigo, or ultramarine, the latter of indigo and burnt terra di Sienna. The colouring of the flesh will acquire additional clearness, by the introduction of reflected lights of a warm or orange colour, finely blended into the cool tints, and the full strength of tone and harmony required, will be given by touches of carmine, ochre, and raw terra di Sienna, in proper places.

When any part of the carnations have too much of any particular tint, so as to injure the harmony of the effect, it will be most easily corrected by the introduction of tints of a directly opposite colour; thus, if too blue, orange, its opposite or contrasting colour, must be introduced; if too red, it must be corrected by means of green, and *vice versa*, and so on of the rest. In the article Accidental Colours, in the first volume of this work, some account of these contrasts of colour will be found, which, though chiefly intended to elucidate a very singular optical phenomenon, affords very important illustration of the laws of the harmony of colour in painting.

The doctrine of the contrast of colour is of the utmost practical utility to the painter, by affording him the means of increasing or subduing the brilliancy of his tints in the most easy and agreeable manner; for the appearance of any given colour in a picture will not be in the ratio of its actual intensity, but will be modified by the colours with which it may be contrasted. Thus white will derive much clearness and brilliancy by being contrasted with black, blue, or grey; yellow with orange, and so on of the other colours and their contrasts.

It is indispensable to the clearness and delicacy of flesh, that transparent colours only should be admitted. The constant white on the eye, and sometimes the brightest light on the point of the nose, are the only parts where opaque colours can with propriety be used.

In finishing the hair, the shadows are composed of a deeper tint of the colour which forms the ground work, its strength being increased by the addition of a greater proportion of the mucilage of gum arabic; the lights may be taken off with the scraper, or a sharp lancet, and filled in with a little transparent colour of a proper tint.

The deepest shadows of the draperies are composed chiefly of transparent colours, worked with an increased proportion of gum arabic, by which the depth and clearness of the colours will be greatly increased. Where great richness in the tints of drapery is required, it will often be found of great advantage to lay one colour over another, instead of mixing them together in one tint, as, for instance, a wash of lake or carmine, laid over a tint of vermillion, will produce a crimson tint, almost equal in depth and richness to oil colours, a process analogous to what is called in oil painting *glazing*. The glazing colour must necessarily be perfectly transparent; and if the tint glazed in this manner be opaque, the richness of the effect will be greater.

In like manner, if any part of the picture has too much of any particular colour, it will be best corrected by a transparent wash of its opposite or contrasting colour; thus, if the red predominate, a transparent wash of green will subdue it, and bring it into harmony; if green be too prevalent, it may be harmonized with red, and so on; and the finishing touches may be added in a delicate manner, so as to bring up the effect to a proper degree of smoothness.

The scientific arrangement of the colours of the drapery in a miniature, is of the greatest importance to its effect. In subjects where delicacy of sentiment ought to predominate, the colours must be modest and sober, without much variety; in gayer subjects, a greater diversity of colour is admissible, without, however, violent contrasts or abrupt transitions, which miniature painting hardly admits of in any case.

In miniature painting, it is of great importance to have a thorough knowledge of the qualities of the various pigments made use of, both as to the tints they form when mixed with one another, and their transparency or opacity, as fitting them for the different parts of the work; for although the same tint may be composed from different pigments, its fitness for any particular part of the picture must be determined by the quality of its grain, its smoothness, transparency, or opacity. Thus, in the carnations, the most delicate and transparent pigments only can be admitted; in woollen stuffs, and other substances of the less flimsy sort, the opaque pigments, (with even an addition of white to increase their consistency,) are most suitable; while in thin light draperies, transparent colours will be most convenient for the shadows, and the lights may be delicately heightened with opaque colours.

The following are a list of the pigments most generally used in miniature painting; and in reference to the above observations, we have arranged them into three classes, viz. Transparent, Semitransparent, and Opaque.

Opaque Colours.

Constant White,	Vermillion,
Flake White,	Indian Red,

Yellow Ochre,	Burnt Umber,
Roman Ochre,	Lamp Black.
Prussian Green,	

Transparent Colours.

Gall Stone,	Carmine,
Gamboge,	Vandyke Brown,
Sap Green,	Sepia,
Brown Pink,	Ivory Black,
Lake,	Indigo.

Semitransparent Colours.

Burnt Terra di Sienna,	Antwerp Blue,
Indian Yellow,	Burnt Ochre.
Ultramarine,	

These colours are usually made up into cakes, and rubbed with water upon a stone plate or tile. The best water colour cakes are those manufactured by Newman & Co. and Smith, Warner & Co. of London.

The colours are diluted to a proper consistency with clean water, and worked with hair pencils.

In water colour painting of every kind, the addition of a very minute quantity of ox-gall to the water, will make the colours work with great ease, particularly where any greasiness occurs. The ox-gall, as procured from the shambles, may be boiled to dryness in a cup, and in this state it may be preserved for any length of time. A small quantity of this substance in the dry state, not larger than a pin-head, will be sufficient for a wine-glassful of water, and with this the colours are to be wrought. The ox-gall may also be preserved for a long time in the fluid state, by mixing it with a little spirit of wine, or other ardent spirit.

It is also necessary to have a small phial of the solution of gum Arabic, which is to be added to the colours, as may be required, particularly where it is desirable to give great depth of tone to the picture.

The chief quality in a hair pencil is, to have great elasticity, and a fine point, without being itself too small. The *sable hair* pencils are the best sort.

When a miniature picture, by repeated working and touching, has acquired any asperities on its surface, it will be necessary to remove them by the dextrous application of the scraper, and any damage that it may have sustained by this process, is easily repaired with the hair pencil, and a little colour. The scraper is also of great use in obliterating small touches, which it would be inconvenient to wash off with water, but if the alteration required is extensive, it is preferable to wash the part with water and hair pencil.

In the execution of a miniature, there are three different modes of laying on the colours, namely, by flat washes, by hatching, and by stippling. The first term sufficiently explains itself, and by this process the greater part of the miniature ought to be executed. *Hatching* is that method by which lines are made to cross each other in every direction, in the manner of a stroke engraving; and *stippling* consists of dots of greater or less size and closeness, according to the effect intended. The hatching and stippling are chiefly to be employed in the more delicate parts of the picture, where much variety and richness of colour are to be given; but they are to be introduced with much caution, so as not to detract from the smoothness or other qualities of surface which propriety may suggest.

With regard to the degree of finishing, which it may be proper to bestow on works of this kind, no rule can be given; and the example of many eminent artists of the British school, sufficiently shews, that with judicious management, guided by sound taste, all the purposes of art may be attained, either with a light and delicate, or a more elaborate style of execution. Upon the whole, we are rather inclined to give the preference to the light, airy, and tasteful style, as exemplified in the works of Mr. Cosway, and Mr. Antony Stewart, of London, which we conceive more suitable to the gay character of miniature painting. The works of Mr. G. Sanders, Mr. A. Robertson, of London, Mr. W. J. Thomson, and Mr. Nicholson, of Edinburgh, afford a striking illustration of the power and brilliancy of colour, and strength of chiar'oscuro, of which this department of art is susceptible.

As water colours are liable to fade by exposure to light, they ought to be covered with a silk curtain, if they are not secured in a cabinet, which is the most proper place for works of this description, particularly miniatures, where they may be preserved for any length of time. A remarkable proof of this is given by the works of Cooper, an eminent English miniature painter, in the time of King Charles the First; those specimens which have been preserved in cabinets have retained all the freshness of colouring for which he was so much celebrated, while those that have been exposed to light have lost all their force.

When a miniature is finished, it is covered with a convex glass, to which it is fixed all round the edge with goldbeater's skin, and thus it may be preserved from injury for any length of time.

In choosing the attitude, the good sense of the artist will naturally direct him to adopt that which will be most agreeable, and most characteristic of his model; and the same principle will regulate the effect of colour, and light and shadow, according as the subject is gay, animated, or grave; and this will be much influenced by the proportion which the light bears to the shadow, and the manner in which they are introduced, as well as by the quantity of warm or cold colour which may be allowed to predominate. Thus the effect will be gay, when the white, delicate yellows, orange, and the other light tints prevail; it will be grave or solemn, when black, blue, and neutral greys form the basis of this effect.

Miniatures on vellum or paper, are executed in the same way as all other water-colour drawings, and as these substances admit of repeated washes over each other, and of blending them together without any risk of washing off the first layers of colour, the processes of hatching and stippling are not so indispensable, although, when judiciously managed, they contribute greatly to the richness of the effect. The only preparation which the paper or vellum requires, is a simple wash of the weak solution of ox-gall already mentioned, which is of great importance in making the colours work sweetly. Whether vellum or paper be used, in subjects of so much delicacy as portraits of the size in which miniatures are executed, it is obvious that that which has the smoothest surface will be the most proper. What is called *Bristol card*, affords the best surface, and most agreeable ground; it is usually of considerable thickness, and is rendered extremely smooth, by means of *hot-pressing*.

Miniature *whole lengths*, are frequently executed in water colours on *Bristol card;* and although this material does not equal ivory in the clearness and depth of tone which it gives, it is, under the hands of a skilful and scientific artist, susceptible of much beauty of effect, and delicacy of finishing. We may mention as a proof of this, Mr. Nicholson's beautiful portraits of Mrs. Scott Moncrieff, and of the Earl of Buchan.

Miniature *whole lengths*, are sometimes executed on Bristol card, the face only being executed in colours, and the rest being finished up to greater or less effect with the black lead pencil. Sometimes the sky and black ground are also delicately tinted with water colours. Formerly, the French and Italian artists painted miniatures entirely in *body* or opaque colours, but as these colours are easily injured, and have none of the depth and brilliancy which are so great a charm in the miniatures of our best British artists, painted in the usual manner, it is now little practised. This mode of art is executed by simply adding *constant white* to the transparent colours, and thus giving them a body. Miniatures have sometimes been painted in oil colours, and this forms by far the most permanent species of art; it was much practised by our countryman Jameson, called the Scotch Vandyke, and he gave to it all the freedom of execution, and beauty of colouring, for which his larger works are distinguished. When miniatures are to be painted in oil, they may be painted on Bristol board, previously saturated with drying oil, on pannel, or plates of copper, which last is certainly the best for this purpose.

Some artists, in painting miniatures on ivory, execute the face only in water colours, in the usual way, and having covered it with a coat of varnish, finish the rest in oil colours; this combination, however, of the two materials, oil and water-colours, is seldom very harmonious; but it is very durable, as the water-colours are not liable to fade, after having received the varnish; but the water-colour miniatures executed according to the process which we have first noticed in this article, must always obtain the preference for beauty of effect, and if properly secured from external injury, and excluded from the light, will be sufficiently durable. (P. G)

MINING. See MINES OF COAL, and VEINS.

MINORCA, MENORICA, or the Smaller, compared with Majorca, is the second of the Balearic isles in point of importance, and is situated in 40° N. latitude, and 30° 45′ E. longitude, about ten leagues to the north-east of Majorca. It is of a long and narrow shape, circular towards the north, and concave on the south coast; about 13 leagues in length, and 38 in circumference. It has been successively possessed by the Carthaginians, Romans, Vandals, Moors, Arragonese, and Castilians; and, for more than a century past, has fallen by turns into the hands of the Austrians, British, French, and Spaniards. Various antiquities are still discernible, and others are occasionally discovered in the island, which indicate the history of its former possessors. In the district of Alayor, is a large round mass of unhewn stones heaped together without any cement, called by the islanders an altar of the Gentiles. There is a cavity at its base, with a low entrance; and on its conical summit, a flat place, capable of containing eight or ten persons. Its origin is ascribed to the Celtic druids. On the summit of Mount St. Agatha, also, are the vestiges of an old fortification, which is considered as a Roman work. Sepulchres, sepulchral lamps, urns, and lacrymatories, small coarse bronze figures, medals, and coins of various nations, are found in the greatest abundance.

The island is generally flat in its surface, particularly on the south coast; and the soil, though rocky or thin, is in most respects tolerably productive. It is much exposed to the north winds, which greatly injure the growth of the trees on that quarter; but snow is seldom seen in the winter season, and the climate during the spring is mild and salubrious. In autumn, the rains are extremely heavy; and in summer, the heat and drought are most oppressive.

The principal mountain is Mount Toro, nearly in the centre of the island, steep and conical, with a flat summit, on which is built an Augustine monastery, to which penitents and pilgrims ascend barefooted at all times of the year. The most remarkable natural curiosities are an extensive grotto near Ciudadella, full of beautiful stalactites; and in its vicinity, a subterranean lake of salt water. Iron ore and lead ore are common, and marble of various qualities and colours. Limestone, full of petrified shell-fish and other admixtures, is very abundant; besides fine blue slate, and excellent white soft stone, which hardens by exposure to the air. Red coral is found in great quantities on the shores; and sometimes the fishers bring up large pieces of white coral in their nets. Fossils and shells are numerous.

The wild animals of the island are chiefly hares, rabbits, and hedge-hogs; but birds of different species are very numerous. The fish around the coast is abundant in all seasons, and of excellent quality. Oysters, and other kinds of shell-fish, are also plentiful and good. Horses are sufficiently common; but mules and asses are chiefly used in riding. The mules are very handsome; and some of them are not less than sixteen hands high. The ass also is of a large breed, and by good management is rendered a very tractable animal. The other domestic animals are horned cattle, sheep, goats, and pigs, of which last considerable numbers are reared in the island. The principal crops are wheat, barley, and a little maize; but fruit of every kind is very plentiful. The olive trees grow spontaneously; but the fruit is used more for pickles, than making oil. Both red and white wines are made from the grapes.

The inhabitants of Minorca have no manufactures or articles of commerce; but might easily produce for exportation, as well as for their own use, cotton, flax, oil, saffron, and quantities of excellent fruit. Their exports consist chiefly of a little wool and cheese, to the value of 2,500*l.* sterling per annum; wax, wine, honey, and salt, to the annual value of above 17,000*l.* The imports are, corn, rice, sugar, coffee, brandy, tobacco, spices, linen, fine cloths, pitch, cordage, and some articles of furniture. The island is provided with the finest harbours in the world, particularly those of Fornella, and Port Mahon, which are capable of containing the largest fleets.

The island is divided into four districts or terminos; and the principal towns are, Ciudadella, Mahon, Alayor, Ferarias, and Mercadel. Ciudadella, the capital, situated to the north-west, with a small harbour, is a very ancient place, tolerably fortified, and containing about 700 houses. Mahon, which is now the principal town, is situated on a rocky promontory, very difficult of access from the land-side, and defended by Fort St. Philip, formerly of great strength, but of late completely demolished by the Spanish government. Alayor, about half-way between Mahon and Ciudadella, is tolerably well built, and is chiefly remarkable for the sculpture and paintings which decorate the interior of its church, and which are the works of a self-taught artist, a native of Majorca. The other two towns are mean villages in the central district of the island. The whole population of the island is estimated at 30,000. The inhabitants are a quiet race. They still preserve among them the skilful use of the sling, for which their ancestors were renowned. They are remarkably attached to their religious ceremonies, and delight in pilgrimages and processions. The dress of the men resembles that of Majorca; but that of the women is rather peculiar. They have very long waists, and short full petticoats. They wear a piece of muslin or crape under the chin, rising on each side of the face till it join a handkerchief drawn tight across the forehead. Over the head is a large piece of muslin hanging down like a cloak; and sometimes they have red mantles tied behind with yellow ribband, under which their hair, tied close at the neck, hangs down like a horse's tail. One of their strangest practices is their mode of churning, which is done by a woman holding by two pegs in the wall to keep herself steady, while with one foot naked she stamps in a tub of cream, till it becomes butter. The possession of Minorca is considered as highly important to the British navy in the Mediterranean.—See Laborde's *Travels in Spain*, vol. iii.; Williams' *Voyage up the Mediterranean*; and Armstrong's *Natural History of Minorca*. (*q*.)

MINOS. See CRETE.

MINSTREL. See BARD, DRAMA, and POETRY.

MINT, is a word used to denote the place where the king's money is coined. In our article COINING MACHINERY, we have already given some account of the English mint, and of the old as well as the new machinery used for the purposes of coinage. We shall, therefore, confine our attention at present to a short notice respecting the mints of England and Scotland, and conclude the article with an account of Mr. Barton's new machine for equalizing the thickness of slips of metals, which has been introduced into the mint since our article on COINING MACHINERY was published.

English Mint.

The early history of the English mint is involved in much obscurity. At a very early period, mints and exchanges were established in various parts of England. In A. D. 928, Athelstane established rules for the regulation of the mints. He enacted, that only one kind of coin should be current, and he granted to different towns a number of moneyers, in proportion to their size, and one moneyer to all burghs of inferior note. When any alteration took place upon the coins, the dies were issued to these mints, for which a regular fee was paid by the moneyers, besides their annual rent.

In the 18th year of Edward II. a considerable change took place. He appointed a master, warden, comptroller, king's and master's assay master, and king's clerk, with several inferior officers, and this constitution continued with but few changes till the year 1815.

In 1798 a committee was appointed to consider the establishment and constitution of his Majesty's mint, and the result of this appointment was the erection of a new mint, with highly improved machinery, between 1805 and 1810.

In 1814 Mr. Wellesley Pole was appointed master of the mint, and drew up a report relative to its constitution, which was introduced in March 1815. The following is a list of the principal officers.

1. Deputy master and warden.	9. Chief engineer.
2. King's assayer.	10 Weigher and teller.
3. Comptroller.	11. Surveyor of meltings.
4. Superintendant of machinery and clerk of the irons.	12. Do. of the money presses.
	13. Probationer assayer.
5. King's clerk and clerk of the papers.	14. Master's second clerk.
	15. Assistant engraver.
6. Master's assayer	16. Mint or bullion porter.
7. Master's first clerk & melter.	17. Warden of the mint.
8. Provost and company of moneyers.	18. Stamper of money weights.
	19. Solicitor of the mint, &c

Our limits will not permit us to enter into any detail respecting the duties of these various officers and the regulations to which they are subject;—details, indeed, which cannot be supposed to possess a higher interest than those which relate to any other great manufactory. Our readers, however, will find the fullest information on this, and all other subjects connected with the mint, in the Rev. Roger Rudding's *Annals of the Coinage of Great Britain and its Dependencies*, in 5 vols. 4to.

Scottish Mint.

The early history of the Scottish mint is very obscure. It consisted probably of very simple apparatus, and few materials, which were kept in the immediate vicinity of the king. The royal prerogative of coinage does not seem to have been ever delegated to subjects in Scotland, and it is explicitly declared to be vested in the king, who, according to a *statute* 1424, *cap*. 24 is to cause new money to be struck when he considers it suitable and profitable for the realm. Various places of coinage appear on the earlier coins, but the principal mint was certainly at Edinburgh, at least from the time that this city became usually the royal residence, and it continued there until the union of the kingdoms. The other mints, if such they can be called, were at St. Andrew's, Perth, Dundee, Aberdeen, Stirling, Dunbarton, Linlithgow, Berwick, Roxburgh, and Annan. The mint of Perth or Dundee was worked before the accession of James VI. It is not explained whether gold was struck elsewhere than in Edinburgh; and the name of the place of the mintage billon, or copper washed with silver, first introduced in the reign of James II between 1436 and 1460, is rarely seen upon it: *Cardonnel Numismata Scotiæ*, p 147. Anciently the mint is denominated the *cunyie house* or coining house, and its apparatus, the *irons*. Therefore, when the reformers in 1559 took possession of the mint, they considered themselves as effectually interrupting its operations, by carrying off the coining irons; and, in a royal proclamation, it is declared, "they have taken, and yet withhold the irons of our cunyie house, which is one of the chief points that concerneth our crown." *Keith's History*, p. 94. *Knox's History of the Church*, p. 301, 302 They defended their proceedings, because the government were impoverishing the country, by issuing a quantity of base money, called hardheads. The same simplicity of apparatus was continued with little deviation until the reign of Charles II. when the coining press was introduced into the Scottish mint; but if the nature of the products be considered, it seems not unlikely that some better mechanical method than merely hammering coins or medals must have been adopted. On the event of the union, Queen Anne issued a warrant in 1707, directing that the officers of the mint should be instructed in the plan pursued by the English mint, and soon after the whole currency was recalled by proclamation, to be recoined.

Some antiquaries conjecture that the earliest Scottish mintage belongs to Alexander I. But it is doubtful whether the silver penny ascribed to him is not of his successors of the same name. Many are seen of William, who reigned 1189—1214, yet nothing is said of the mint until the time of David II. in 1329—1371. Then a statute ordains a new coinage, with a distinguishing mark, *signum notabile*, that the chamberlain shall agree, on part of the king, with the coiner, (*monetarius*) and the workmen; and the warden, (*custos monetæ*) and master of the money or master coiner, (*magister monetarius*,) are also named: *Statute, Dav. II. cap.* 38. 46. In this reign, the mint perhaps subsisted on a regular establishment, for certain privileges, such as exemption from taxes, sitting on juries, and other burdens, are conferred on Adam Tore, warden, James Milliken, mint-master, and their servants, by a charter dated in 1358. These privileges were renewed by James V. in 1542 and his successors, and so lately as the year 1781, the officers of the mint proposed to take advantage of them. The number of officers, and the nature of their duties, were different at different times. At length the establishment is described, in an act of Privy Council in 1567, as consisting of a general of the coining house, master coiner, warden assayer, and sinker, together with melters, forgers, and printers; and it is described nearly in the same terms in *statute* 1597, *cap.* 249. with the addition of another officer, the counter warden. By the *articles of the Union*, § 16. it is provided that the establishment shall be subsequently preserved on the same basis as before it, and now the officers consist of general, master, counter-warden, assayer, and smith. It is not evident, when the denominations of the diffierent officers was bestowed, from which alone a correct history of the establishment could be deduced. In the records we find appointments to the office of general in 1559, and afterwards of master of the coining-house in 1538, warden in 1539, counter-warden 1542, master-coiner 1565, sinker or hacker of the irons 1546, keeper of the king's coining irons 1525, assayer 1329—1370. This last office was then granted to John Goldsmith, burgess of Edinburgh. Mr. Rudding observes, that he has obtained the name of only two wardens of the Scottish mint, but we have remarked so many, that there seems to have been a regular succession from a very early period. Indeed, the duties of this officer, and those of the counter-warden, have been always very important. By *Stat.* 1483, § 93, it is enacted, that the king shall appoint a wise man, that has knowledge in money, to be warden, who by *Stat.* 1551. § 33, 58. is rendered responsible for the quality of the coinage. He is to furnish the master-coiner, who is made responsible for the quantity of the coinage, with bullion, and keep an account of the number of ounces struck yearly, *Stat.* 1488. It has been affirmed, that foreigners were employed as engravers to the Scottish mint of old, but we have been able to find very few, if any, such. Briot, a French artist, was employed to engrave the dies for the coronation medal of Charles I. in 1633, and the successors of this sovereign commanded the celebrated Thomas Simon, in 1662, to make puncheons for gold and silver coinage in the Scottish mint: *Vertue, Works of Simon, Appendix*, p. 71. The abilities of the artists were exceedingly various, and the erroneous legends prove their ignorance of the language, regarding which they were employed; thus, on the coins of James IV. 1488—1513, for Rex Scotorum, we see, Rex *Cot, Cotto*, or *Cotru*. The quality of the products of the Scottish mints, however, was not inferior to what came from some of the cotemporary mints in Europe, and in the sixteenth century, probably surpassed those of England. Many of the dies are said to have been recently in preservation. A great quantity of base coin was continually in circulation; and, notwithstanding successive ordinances that the national coinage should be of the same weight and fineness as the English, there were many complaints in England of its inferiority. Its circulation there was prohibited, but it was allowed to be brought to the mint as bullion. *Rudding—Annals of the Coinage*, vol. i. p. 443, 484. The numerous forgeries in Scotland led to a penal statute against "forging the king's irons;" and magistrates were enjoined to establish "sufficient clipping houses" where the "clipper" was to have a certain remuneration for destroying false money. *Stat.* 1540, *cap.* 124.—1567, *cap.* 19.

From the strict prohibitions against exporting the precious metals, and the anxious enactments for their import under inspection of the warden, the mint evidently laboured, in general, under a deficiency of bullion. However a very fine coinage from the native gold of Scotland was issued by it in the year 1539, in what are called bonnet pieces. Nearly two centuries antecedent to that period, a gold coin or medal was struck of David, which has been supposed English workmanship; and in 1478 a gold medal of James IV. weighing two ounces, was struck at Berwick, and sent by him to the shrine of a saint in France.—*Pinkerton on Medals*, vol. ii. p. 113. At this latter period the native gold was separated from the sand by washing; and it is affirmed that, in the subsequent reign, Germans repairing hither in quest of that metal, had engaged 300 persons in their service, and recovered as much as to afford large sums to the king. In the earlier years of James VI. Cornelius Devosse, a German lapidary in London, obtained a grant of the gold mines in Scotland, from the recommendations of Queen Elizabeth, on condition that the whole gold procured by him should be carried to the mint. The subject continued to attract much attention after the union of the crowns, more, perhaps, than it merited. A master of all mines and minerals was appointed in 1607, and the gold and silver mines of Lesmahago were bestowed on the Marquis of Hamilton in 1620.—*Records of the Privy Seal.* In 30 days, eight pounds of native gold were brought to the mint, by the German lapidary, where it was coined into L.3 pieces, each an ounce in weight. All of these, which could not exceed 100 in number, have utterly disappeared. The workmen also obtained gold, which they sold for 20 shillings Sterling an ounce. Besides what was brought to the mint, it is said in the Manuscripts of Atkinson on this subject, who was personally concerned, that a partner in the mining concern got as much native gold as enabled an artist in Edinburgh to make "a fair deep bason," capable of holding an English gallon to the brim, which the Earl of Morton presented full of gold unicorns to the king of France, assuring him that both were from the native gold of Scotland. It is not recorded by any other author, that the mint produced that coin, the unicorn, of Scottish gold. Another contract seems to have been made with a different foreigner, wherein provision was made in like manner for supplying the mint. Atkinson affirms that Mr. Bulmer, afterwards Sir Bevis Bulmer, presented a porringer, made of Scottish gold, to Queen Elizabeth, and alludes to a coinage different from the former. Somewhat later, namely in 1633, a fine medal of Scottish gold, issued from the Edinburgh mint, on the coronation of Charles I. inscribed around the edge, EX AURO UT IN SCOTIA REPERITUR. There was no gold coinage in the two reigns succeeding; and the last in Scotland was that of William III. in 1701, struck from some gold sent home by the Scots Darien Company. Native gold is still found in small quantities in Scotland. But though silver has been frequently extracted from lead-ore, and though Atkinson gives an account of the finding and losing of a rich silver-mine at Hilderstone, in the county of Linlithgow, we have not heard of any coinage from it.

Perhaps no documents are extant which shew the total coinage in any of the metals issuing from the mint during the reign of any of the Scottish sovereigns; nor is it probable that either bullion or money ever could be abundant in a country alike destitute of domestic products and foreign commerce. William the Lyon having been taken prisoner, was ransomed for 40,000 merks, and David II. nearly two centuries after, was ransomed for 100,000, which must have drained the nation of a large portion of the currency, and led to the employment of the mint for the special purpose of producing it. Attempts have been made to prove that great advantage was derived from a monopoly of trade with France. "Nay," says one author, "who would believe it, were it not demonstrable from unquestionable vouchers, the records of the mint, so immense were our profits this way, that, in the reign of James VI. we coined 119 stone-weight of gold, and 986 of silver, within the space of one year." *Preface of the Translation of Beague's Campaigns*, p. 28. From a few authentic details of the operations of the mint, which have occurred to us, we incline to conclude that the quantity of gold within the period specified, is somewhat overrated, but that the computation of silver is not so.

Between November 1583 and April 1585, inclusive, the mint coined 6 stone, 13 lb. 10 oz. of gold into lyon nobles, the metal being computed at 16 pounds per stone; and the coinage of the fineness of 21½ carats. From the 4th of November 1592 to the 18th of January 1594, the mint consumed 12 stone, 2 lb. ½ oz. in a coinage of 4*l.* pieces, which were struck at 35 different times. Within the same period, there were likewise struck in "Thistle nobles," of which we have never seen either a specimen or a figure, five pounds six ounces on the 10th of November, 1593. The quantity of gold daily used on these occasions varied from 19 ounces, to 11 pounds 4 ounces. *Manuscript Accounts of the Mint*. From 16th December 1602, to 19th July 1606, and from 20th September 1611, to 14th April 1613, the mint struck 51 stone 11lb. 9 oz. of gold. *Ruddiman's Preface to Anderson's Diplomata*, p. 85. If the quantity of 119 stones be actually overrated, it is not inconsistent to believe that the author may have made up his calculations from several portions of successive years, and by combining them, he may have conceived that 119 stone were coined in the space of one year. Gold was rated at a very high price.

On certain occasions, the consumption of silver was very considerable, and it is also probable that the preceding computation of the whole during a year of the reign of James VI. at 15,776 pounds of bullion is within the truth. Regarding this also, we find only a few detached notices preserved. Being rated at too high a value, the *statute* 1581, *cap.* 107, recals a late coinage which had been struck from 211 stone, 10 lb. of silver, and the mint proceeded to strike 548 stone, in ten, twenty, thirty, and forty shilling pieces, between 7th April, 1582, and 1st February, 1583. From the 1st of May of that year until the 1st of October of the year following, 264 st. 12 lb. of silver was consumed in pieces of the same denomination. No less than 1138 st. 10 lb. seem to have been converted into eight and four-penny groats of three deniers fine, during the first nine months of 1584, and 217 st. 7 lb. into penny and two penny pieces, in the first three months of 1590, though, during the two preceding years, the mint was in great activity. Ruddiman observes, that, notwithstanding 596 st. 7 lb. 13 oz. of silver was used in the periods above mentioned, between 1602 and 1612; the value of the gold coinage within the same period, surpassed it by 1554*l.* sterling. The quantity of silver consumed by the mint was therefore very considerable; and we find it employed in a coinage during 1694 and 1695, when both the weight of silver, and the number of pieces struck, were all distinctly enumerated in the books of the counter warden.

For the purpose of supplying the mint, in the 17th century, a duty was imposed, first on exports, and then on imports also, of a certain quantity of bullion, which the trader had it in his option to pay in money, at the rate of a shilling an ounce. Thus the exporter of 20 sheep was taxed with two ounces of bullion, and the importer of French wines, twelve ounces per ton. They did not supply the bullion, however; but the mint, during most of the reign of Charles II. seems to have coined about 200 stone of silver yearly.

During the same reign, it was authorised to employ 6000 tons of copper in coinage. Many abuses prevailed, and the officers whose province it was to supply both that metal and bullion, converted not less than 40,000 stone to money, obtaining from every pound the value of three shillings Sterling.

At the date of the Union, the old silver currency being recalled for the purpose of a new coinage, there came in 142,180*l.* Sterling of hammered money, and 96,856*l.* of milled money, which latter must have been executed subsequent to the succession of Charles II. The operations of the mint were suspended on the death of his predecessor, which the commissioners from Scotland represented to Parliament, occasioned an extreme scarcity of money, and it ceased to work a short time subsequent to the union of the kingdoms. (*c.*)

Description of Mr. Barton's New Machine for equalising the thickness of Slips of Metal for making Coin.

Fig. 1. of Plate CCCXCVII. represents a side elevation of the machine, as it would appear when in action, and Fig. 2. a horizontal plan of it. This machine operates in the same manner as wire drawing-machines, viz. by drawing the slips of metal forcibly through an oblong opening formed between two surfaces of hardened steel. The box or case which contains the steel dies, and also the pinchers employed to hold the metal and draw it through, are represented on a larger scale in fig. 3, 4, and 5, on the plate. Fig. 3. shews a section of the die-box, and elevation of the pinchers. The dies are composed of two cylinders, *a*, *b*, made of steel; they are rendered extremely hard and very straight upon

their surfaces, being highly polished; these cylinders are fitted into convex cavities formed in the pieces of metal A, B, and are retained in their places by clamping pieces *c*, *c* pressing against them, by which means the steel cylinders are firmly supported, and prevented from bending during the violent action of the metal while passing between them. The pieces of metal A, B, are fitted into a box C of cast iron, so as to bear flat against the bottom of the same, and are secured by bars, *e*, *e*, screwed across the front, as seen in Fig. 5. which represents a front view of the box containing the dies, the lower piece B rests upon the ends of three screws, *d*, *d*, *d*, which pass through the metal of the box C, whilst the upper piece A is forced down by the action of a large screw D, which has a toothed wheel N upon its uppermost end, with a pinion and lever to turn it round by and adjust the distance between the dies; the screw D is furnished with a clamping nut *f*, to remove any shake which might remain in the threads of the screw; the pieces A and B are confined sideways by small screws *g*, *g*, pressing against them very forcibly; *h*, *h* represent two extending screws, which are introduced between A and B, to force them asunder, and bring them into firm contact with the ends of the screws D and *d*, *d*. *d*. The box containing the dies is fixed at one end of a long horizontal frame, as seen at C, Fig. 1. and strengthened by cast-iron brackets, *i*, *i*, Figs. 1. and 2. The frame is furnished with adjusting bearings, *k*, *k*, at each end, to support two axes E and F, which have wheels fixed upon them adapted to receive endless chains of metal of the form seen at *l*, *l*; which lie in channels formed along the surface of the frame. A large cog-wheel G is fixed upon the axis F, to give motion to the endless chains; this cog-wheel is turned by a pinion H, fixed upon an axis *m*, extending across the top of the frame, and working in bearings at each end; a cog-wheel I is fixed upon the axis *m*, and works into the teeth of a pinion K, upon a second axis across the frame, which also carries a drum-wheel L, for giving motion to the whole machine by an endless strap. Fig. 3. and 4. represent the pinchers which take hold of the slips of metal and draw them through the dies. The two jaws of the pinchers are united by a joint pin *n*, which projects on each side of the pinchers, and is furnished with small wheels or rollers, *o*, *o*, Fig. 4. to run along the edges of the channel formed upon the frame. In order to receive the endless chains, *p*, *p* are two wheels similar to *o*, *o*, but are fixed upon an axle which passes through between the tails of the pinchers; the axle of the wheels *p*, *p* is attached to strong links of iron *q*, *q*, the ends *t* of which are formed like a hook to take hold of the rounds of the endless chains so as to draw the pinchers along with it; the pinchers are situated over the endless chains, and will run backwards or forwards upon their wheels. They are caused to gripe the slips of metal firmly between their jaws by the axle of the wheels *p*, *p*, acting between two inclined planes formed upon the insides of their tails. The links *q*, *q* are furnished with a weight *r*, which operates to raise the hooked part *t* above the links of the endless chains, whenever the strain upon the pinchers ceases by the slip of metal having passed through and out of the dies. The slips of metal to be operated upon by the drawing machine are first rendered thinner at one end, in order to introduce them between the dies and between the jaws of the pinchers. This thinning of the ends is effected by the machine represented at Fig. 6. in the plate; it consists of a small pair of rollers mounted in an iron frame, similar to a rolling-mill. The upper roller A is cylindrical, whilst B is formed with three flat sides, leaving only portions of the cylinder entire, between the flat sides, the distance between the centres of the rollers is regulated by screws having wheels on their upper ends in the manner described for the drawing dies C in Fig. 1, 2, &c. The rollers have pinions upon their axes which cause them to turn round together; they are put in motion by an endless strap passing round a drum, upon the axis of which is a pinion working into the teeth of a wheel fixed upon the axis of the lower roller B.

The end of a slip of metal is presented between the rollers whilst they are in motion, not on that side of the roller which would operate to draw the slip in between them, as in rolling mills, but on the contrary side, so that when one of the flat sides of the roller B comes opposite the circumference of the roller A, an opening is formed, through which the end of the slip of metal is to be introduced, until it bears against the fixed stop *b*. at the back of the rollers; now as the rollers turn round, the cylindrical portions come opposite, and press the metal between them, forcing it outwards, rendering the part which has been introduced between the rollers as thin as the space between their cylindrical surfaces, which allows the end of the slip of metal to be passed between the dies of the drawing machine to be seized by the pinchers.

In using the drawing machine, a boy takes hold of the handle *s*, (when the hook *t* is disengaged from the endless chain) and moves them upon their wheels towards the die-box C. This causes the jaws of the pinchers to open by the two pins, *v*, *v*, which are fixed across between the links *q*, acting upon inclined parts outside of the pincher tales, as seen in Fig. 3. The pinchers are pushed up so close to the die box, that their jaws enter the cavity *w*, which brings them near the dies, in order to seize the end of the slip of metal introduced between them. The boy now holds the handle *s* upon the top of the pinchers fast, and with the other hand draws the handle *x*, at the end of the link *q*, backwards. This closes the jaws and gripes the metal. He then presses down the handle *x* till the hook *t* seizes the endless chain whilst in motion, and carries the pinchers and slip of metal along with it; when the whole length of the slip of metal has passed through between the dies, the strain upon the pinchers is suddenly relieved, which causes the weight *r* to raise the hook *t* above the chain, and stop their motion. The machine in the mint has two sets of dies, and endless chains, as will appear from Fig. 2.

The following information relative to the Mint of the United States, has been furnished by Robert Patterson, Esq. the present Director of that institution.

Mint of the United States, at Philadelphia.

This institution was established by an act of Congress passed the 2d day of April, 1792.

The officers of the mint are, at present, a director, a treasurer, a coiner, an assayer, a melter and refiner, and an engraver, with one clerk. for the whole institution.

The coins to be struck at the mint, as established by law, are, in gold—eagles, (10 dollar pieces.) half eagles, and quarter eagles; in silver—dollars, half dollars, quarter dollars, dimes, and half dimes; and, in copper—

cents, and half cents. Gold and silver are coined for individual depositors only; copper, on account of the government, but to be transported in exchange for an equal amount in specie, or paper receivable at the bank of the United States, to all parts of the United States, at the expense and risk of the government.

The amount of coinage, in different years, depends on that of the deposits. In the year 1820, the number of pieces coined was 6,492,509, amounting to $1,864,786.

The machinery is moved by a steam-engine.

The drawing-machine, for equalising the thickness of the slips of metal, is precisely the same as that described in page 614 of this Encyclopedia, called "Berton's New Machine," and has been in use since the year 1793.

MIRACLES. See TESTIMONY.

MIRAGE. See OPTICS and REFRACTION.

MIRRORS. See KALEIDOSCOPE and OPTICS.

MISSIONS. In this article we propose to give a general view of the attempts made by the Protestant churches for the propagation of Christianity among heathen nations: Of the principal missions established by the Church of Rome, some account may be found in our history of those countries which were the scene of them. See ABYSSINIA, ANGOLA, CALIFORNIA, CANADA, CHINA, JAPAN, &c.

In 1559, the celebrated Gustavus Vasa, king of Sweden, sent a missionary of the name of Michael into Lapland, with a view of extending Christianity in that country; for though it had been introduced some ages before the reformation, yet most of the inhabitants were still little better than Pagans. But though it is now nearly three centuries since the Swedes began to extend the gospel in Lapland, it has hitherto made small progress. The inhabitants, indeed, are professed Christians; but the Christianity of most of them is merely nominal, and among some of them the form of it may be sought in vain.

In 1716, Frederick IV. king of Denmark, sent two missionaries into Norwegian Lapland; and, according to the accounts which are given of that part of the country, the inhabitants are better provided with the means of Christian instruction than those of Swedish Lapland; but we suspect religion has made no great progress among them.

In 1802, the Edinburgh Missionary Society* sent the Rev. Henry Brunton and Alexander Paterson on an exploratory mission to the countries lying between the Black and the Caspian Seas. The Russian government favoured the undertaking, and afforded them every assistance and encouragement. This mission now consists of three branches, Karass, Astrachan, and Orenburg; and it is in contemplation to establish a fourth in the Crimea. Besides writing a number of small works in the Tartar language, Mr. Brunton translated into it the New Testament; and a version of the Old Testament is now carrying on by the other missionaries. Of these, large editions were printed, and extensively circulated through the regions of Tartary. Several of the natives have embraced Christianity; and, among others, one of the sultans of the country, a young man of highly respectable talents, and who is connected with some of the principal families in the East.

In 1705, Frederick IV. king of Denmark, sent Bartholomew Ziegenbalg and Henry Plutscho to Tranquebar, with the view of converting the Hindoos to the Christian faith. Though the undertaking met with much opposition and obloquy, particularly from the Europeans and Roman Catholics in India, yet it was fostered with parental care by his majesty, and finally triumphed over every obstacle. This mission now consists of four branches, Tranquebar, Vepery near Madras, Tritchinapoly, and Tanjore. Since its commencement, about 54,000 of the natives, as nearly as we can estimate them, have been baptised or received by the missionaries. It is a common idea that the converts consist almost entirely of the race of Pariars; but though this was the case in the first years of the mission, the state of things is now materially altered. At Tranquebar, Vepery, and Tanjore, more than two-thirds of them are of the higher casts; and even those of the lower order are so much improved, that were a stranger to visit their places of worship on the Sabbath, he would be surprised at the cleanliness of their appearance, and might even mistake them for the higher class of Hindoos. It has often been alleged, that any attempt to convert the inhabitants of Hindostan to Christianity would alarm their prejudices, and even endanger our dominion in the East; but the missionaries on the Coast of Coromandel have pursued their peaceful labours for upwards of a century, without ever exciting the slightest commotion among the Hindoos or Mahomedans, and have even acquired, in a remarkable degree, their respect, and confidence, and love. On the monument erected by the East India Company to the memory of Mr. Swartz, who died about twenty years ago, it is stated that the late Hyder Ally, in the midst of a bloody and vindictive war with the Carnatic, sent orders to his officers "to permit the venerable Father Swartz to pass unmolested, and shew him respect and kindness, for he is a holy man, and means no harm to my government." Such, indeed, was the high estimation in which he was held by all classes of the natives, that Colonel Fullarton assures us, that "the knowledge and integrity of this irreproachable missionary had retrieved the character of Europeans from the

* The following is a list of the principal institutions among the Protestant churches, which have supported missions among the heathen:

The Corporation for the Propagation of the Gospel in New England, and the adjacent parts of America, erected 1649. Of this Society the Hon. Mr Boyle was about 30 years the governor.
The Society (in London) for promoting Christian Knowledge, instituted 1698.
The Society for the Propagation of the Gospel in Foreign Parts, incorporoted 1701.
The Society in Scotland for propagating Christian Knowledge, incorporated 1709.
The Royal Danish Mission College.
The Moravians or United Brethren, 1732.
The Methodist Missionary Society, 1786.
The Baptist Missionary Society, instituted 1792.
The London Missionary Society, instituted 1795.
The Edinburgh (now the Scottish) Missionary Society, instituted 1796.
The Church (of England) Missionary Society, instituted 1799.
The American Board of Commissioners for Foreign Missions, instituted 1810.
The Baptist American Board of Commissioners for Foreign Missions, instituted 1814.

imputation of general depravity." (Fullarton's *View of English Interests in India*, p. 183.) Besides compiling various works of a philological and religious nature, the missionaries translated the whole Bible into the Tamul and Telinga languages; the Old Testament into that dialect of Portuguese which is spoken in India; and the New Testament, together with some parts of the Old, into Hindostanee.

In 1793, the Baptist Missionary Society sent the Rev. William Carey and Mr. John Thomas to Bengal, with the view of attempting the conversion of the Hindoos in that part of India. For several years they laboured without any apparent success; but since the commencement of the present century they have baptised a considerable number of the natives; and though some of these afterwards relapsed into Paganism, yet the great body of them remained stedfast to their Christian profession: their character was on the whole materially improved by Christianity, and was in many respects ornamental to it. Serampore, a Danish settlement about fifteen miles from Calcutta, was the grand seat of this mission; but within these few years, numerous branches have been established in different parts of the country, which promise to contribute essentially to the extension of Christianity among the Hindoos. The grand work, however, for which the Baptist Missionaries are distinguished, is the translation of the Scriptures into the languages of the East. Here they are without a parallel, either in ancient or modern times. Under the superintendence chiefly of one individual, Dr. Carey, the Scriptures are translating into upwards of FORTY different languages. The *whole Bible* has already been published in the Sungskrit, the Bengalee, the Orissa, the Hindee, and the Mahratta; and the *New Testament* in the Chinese, the Shikh, the Telinga, the Kunkuna, the Affghan, the Asamese, the Mooltanee, the Kurnata, and the Guzerattee. Besides translating the Scriptures into so many languages, Drs. Carey and Marshman have published many works of a literary nature, which form a stupendous monument of their talents, and diligence, and zeal, and which will be of essential service to their successors, in learning the languages, the principles, and the manners of the natives, and thus may be of important use in advancing Christianity in the East. Dr. Carey is professor of the Sungskrit, Bengalee, and Mahratta languages, in the College of Fort William, and with singular disinterestedness, devotes his salary, amounting to about 1500*l.* a-year, to the funds of the mission. Two others of the missionaries, Marshman and Ward, contribute nearly an equal sum annually to missionary purposes. Within less than twenty years, the missionaries themselves have devoted upwards of FIFTY THOUSAND POUNDS to the objects of the mission.

Within these few years the London missionary Society, the Church Missionary Society, the Methodist Missionary Society, and the American Board for Foreign Missions, have all directed their attention to Hindostan, and have established numerous stations in that extensive and interesting country. Hitherto no particular success has crowned their labours; but the measures they are pursuing promise silently to sap the foundations of Hindooism, and to pave the way for the establishment of Christianity. Among these we may particularly notice the extensive scale on which the education of the young is conducted. This is an object to which the missionaries direct much of their attention, and their exertions promise to be attended with the most favourable results. In some of the schools the Scriptures are employed as a school-book, without the natives making any objection to them, or if prejudices against them existed at first, they soon subsided. In others they are not used, lest this should excite opposition among the natives, and defeat the whole plan. The teachers are generally Hindoos, some of them Brahmins, but it is necessary to maintain a strict superintendence over them, as without this they are sure to neglect their duty. The number of schools connected with the different missionary stations in India amount to about 300, in which are educated upwards of EIGHTEEN THOUSAND children.

About the middle of the 17th century the Dutch introduced the Protestant faith into the island of Ceylon; but unfortunately the measures they employed for its propagation were in some respects extremely reprehensible. Besides settling ministers, and establishing an extensive system of schools on the island, they issued a proclamation, ordaining that no native should be raised to the rank of a modeliar, or admitted to any employment under government, unless he subscribed the Helvetic Confession of Faith, and professed himself a member of the reformed church. In consequence of this absurd and impolitic order, vast numbers of the Cingalese abandoned the religion of their ancestors, and embraced the faith of their conquerors. Even in 1801 the native Protestant Christians in Ceylon still amounted to upwards of 342,000, according to the general return in the ecclesiastical department; but in 1813 there were only, according to a similar return, about 146,000. The fact is, that a large proportion of those who are called Christians are in reality heathens; for though they have been baptised in their infancy, they are totally ignorant of the principles of the gospel, and are worshippers of the idle Buddhu. Not a few avow themselves both Christians and Buddhists, and are willing to be sworn as either the one or the other in a court of justice.

Within these few years a considerable number of missionaries of various denominations have settled in Ceylon, and have been patronised in the most liberal manner by the British government. Among these the Methodists have been singularly distinguished by their activity and zeal. In 1819 they had formed no fewer than thirteen or fourteen missionary stations in different parts of the island; and in the schools which they had established there were 4484 children, of whom several hundreds were girls; a circumstance which is the more interesting, as in Ceylon, females, notwithstanding their great importance in society, were in general excluded from the blessings of education.

To Java, Amboyna, Sumatra, Timor, Celebes, Formosa, and others of the eastern islands, on which they established themselves, the Dutch in the 17th century sent ministers to convert the inhabitants to the Christian faith. Vast multitudes of the natives, as in Ceylon, submitted to baptism; but most of them, we suspect, might nearly as well have retained the religion of their ancestors. In Java alone the number of Christians was upwards of 100,000; and in the Molucco Islands there are still probably not fewer than 40,000; but for many years past they have been much neglected, and are now in a great measure destitute of the means of religious instruction. Several missionaries, however, have of late been sent from Holland to these islands, and editions of the Scriptures in Malay are preparing for the use of the inhabitants.

In 1807, the Rev. Robert Morrison was sent by the London Missionary Society to Macao, with a particular view to the translation of the Holy Scriptures into the Chinese language. In learning the language he had to make it as much a matter of secrecy as if he had been plotting the overthrow of the government; the persons who assisted him trembled for their own safety, should they be discovered. In January, 1814, he published the New Testament, part of it translated by himself, and part of it taken from a valuable MS. in the British Museum, a transcript of which he carried with him from England. He now proceeded with a translation of the Old Testament, and it is expected that it will soon be completed. Besides these works, Dr. Morrison published several others, chiefly of a philological nature, with the view of assisting the future student in acquiring the Chinese language. In April 1815, the Rev. William Mylne, who had been sent out to assist him in his labours, proceeded to Malacca with the view of establishing a branch of the Chinese mission in that country, as they found themselves greatly restricted in their labours at Macao. Here he was joined by other missionaries, and an extensive establishment was formed by their united exertions. They instituted schools for Chinese, Malay, and Malabar children; they printed various works in the Chinese and Malay languages; they forwarded them in great numbers to the different settlements in the archipelago where the Chinese resided, to Siam, Cochin-China, and even to China itself: and they are now erecting a college for the cultivation of Chinese and European literature.

In 1792, the Moravians, or United Brethren, sent missionaries among the Hottentots in the neighbourhood of the Cape of Good Hope. Here they at first met with violent opposition from many of the colonists: the grossest calumnies were circulated with respect to their designs, and a conspiracy was even formed against their life. The success, however, with which their exertions were crowned, amply recompensed them for all the difficulties and trials which they encountered during the first years of their residence in that country. They have now two flourishing settlements, the one about 120, the other 40 miles from Cape Town; and they lately began a third near the borders of Caffraria. Since the commencement of the mission, they have baptized about two thousand of the Hottentots, a large proportion of whom, we have reason to suppose, are an ornament to their Christian profession. Besides christianizing so large a number of these wretched outcasts of society, they have been singularly successful in improving their external condition, and in promoting civilization among them. Bavians Kloof, the first settlement which they established in this country, lies in a valley surrounded by high mountains, watered by the river Sonderend and several smaller streams. When the missionaries first settled at this place it was a perfect wilderness, yet such are the improvements they have made upon it, that it now looks like a kind of paradise. Some of the Hottentots' houses consist of four apartments, which are white-washed, and look remarkably neat and clean; others are still mean and dirty. To every house is attached a garden, surrounded with bright green quince hedges, and full of peach and other fruit trees, the bloom of which perfumes the air with its delicious fragrance. Their growth is so rapid and promising, that, in the cultivation of his garden, many a Hottentot has lost his national character of idleness and sloth, and acquired a relish for an active industrious life. The whole settlement is about a mile in length, and a quarter of a mile in breadth. The gardens are so numerous and so beautiful, that the whole looks like a city in the midst of a wood. "But in order," says Dr. Lichtenstein, in his Travels through Southern Africa, "to form a just estimate of these excellent men, their manner of conducting themselves to the Hottentots must be seen: the mildness, yet dignity with which they instruct them, and the effect which has already been produced in improving the condition of their uncivilized brethren, is truly admirable. It is the more astonishing, since all has been accomplished by persuasion and exhortation: no violence or even harshness has ever been employed." It has been often stated as a circumstance highly honourable to the Moravian missionaries, that in their missions among barbarous tribes, they endeavour to civilize them before they attempt to christianize them; but nothing could possibly be more contrary to fact. With them Christian instruction is from the very first the primary object, and is considered as the grand engine of civilization. Both, in fact, are carried on at the same time, and have mutually a powerful influence in promoting each other,—a plan unquestionably much more rational than that which is commonly attributed to them, and for which they have obtained so much credit. In 1819, the new settlement which the Brethren had formed near the borders of Caffraria, was entirely destroyed by the Caffres in the course of their late eruptions into the colony: several of the Hottentots were murdered, and upwards of 600 head of cattle belonging to them and the missionaries carried away; but since the restoration of peace, the Brethren have again returned to that part of the country.

In 1798, Dr. Vanderkemp, a Dutch physician of considerable eminence, and three other young men, were sent by the London Missionary Society to South Africa. In that country this Society has now no fewer than twelve settlements, some of them within the colony of the Cape of Good Hope, others beyond its boundaries. At these different places, many thousands of heathen of various nations have enjoyed the benefit of Christian instruction; and upwards of fifteen hundred have been admitted by baptism into the bosom of the church. Dr. Vanderkemp, and others of the missionaries, have been censured for neglecting to promote civilization among the people under their care; but though there appears to have been some foundation for the charge, they were by no means so negligent in this respect as their enemies alleged. As the Hottentots were extremely indolent, it was early a maxim with them to teach them the necessity of industry, by allowing them to feel the sorrows of want, and to give them nothing but what they earned by their own labour, except such as, through age or sickness, were unable to work. The beneficial effects of this system was evident in the improved habits of the people, and in the vast increase of their wealth. They not only possess large herds of cattle, sheep and goats; but, where it is practicable, have cultivated considerable tracts of land, and planted excellent gardens. Of late years, the missionaries, in consequence of the accusations which were brought against them, have paid more particular attention to the civilization of the people under their care; and, though they have many obstacles to encounter, yet in some of the stations the progress of improvement has been uncommonly rapid.

In 1804, the Church Missionary Society sent missionaries to Sierra Leone, with the view of introducing Christianity among the neighbouring Susoos. From several of the chiefs they met with the kindest reception, and the greatest encouragement; but to others, their proposal of teaching them "good things" seemed very unaccountable, and even almost ridiculous. What they had hitherto known of white men, prepared them to view with surprise and suspicion any desire of Christians to settle among them with a benevolent design. The object to which the missionaries principally directed their attention, was the education of the young,—a measure which they pursued on an extensive scale, and with considerable success. But while they prosecuted their labours with disinterestedness and zeal, they had to struggle with difficulties of no ordinary kind, most of them arising out of the iniquitous traffic in slaves. It may appear to us a very extraordinary circumstance, that the inhabitants of Africa should cling to that as a blessing, which we had abolished as her greatest curse; but the fact is, the slave trade had, from time immemorial, been the main support of the country, and the removal of the slave factories stopped the whole trade of the natives, which could not fail to be felt as a serious evil, until some other profitable traffic was established. Hence they hailed the appearance of a smuggling vessel on their shores, and, on a short notice, supplied her with a cargo of slaves in exchange for tobacco and powder and rum, which quickly spread idleness, disorder, and misery, through the whole country. The governor of Sierra Leone having sent armed vessels to destroy the slave factories, and to capture the smuggling ships, the Susoos became extremely exasperated against the missionaries, imagining it was they who communicated information to him of the arrival of smugglers on the river, though they in fact scrupulously avoided interfering in matters of this description. The two settlements which the missionaries had established in the country were burnt to the ground; and the enmity to them became at length so general and so violent, that in 1818 they retired with a considerable number of the children to Sierra Leone. A similar establishment, which was formed on the Bullom shore, was also abandoned, chiefly in consequence of the pernicious influence of the slave trade.

But while the slave trade has unhappily blasted the prospects of the Church Missionary Society in the Susoo country, and on the Bullom shore, it has opened to them a wide and important field of usefulness in the colony of Sierra Leone. After the abolition of this iniquitous traffic, multitudes of negroes, captured in smuggling vessels, were brought to Freetown, and, as they were in a most wretched forlorn condition, they were settled in towns in different parts of the colony, and were supplied with food and clothing at the expense of government, until they were able to maintain themselves. In the principal of these towns the Church Society established missionaries and schoolmasters, who are proceeding in their labours with every prospect of success. In January 1819, the number of adults and children attending the schools in Sierra Leone was no fewer than 2104.

In 1721, Mr. Hans Egede, a Norwegian clergyman, proceeded to Greenland, with the view of attempting the conversion of the inhabitants to the Christian faith. There, amidst numberless difficulties, and hardships, and dangers, he laboured with unwearied patience and perseverance, but with little appearance of success. Though the Greenlanders often listened to him with wonderful attention, and approved of all he said, it was evident they understood little of his instructions. It is worthy of notice, however, that the immortality of man was a favourite doctrine with them. It pleased them to hear that the spirit did not die with the body; that the body itself would be restored to life at the last day; that friends would meet together in another and a better world; and that they would be no more subject to sickness and sorrow. In Greenland, the Danish government afterwards established a number of other colonies, (See Art. GREENLAND,) and in the principal of them supported missionaries. Many of the Greenlanders have now embraced the Christian faith, and its beneficial influence is obvious in promoting civilization among them; there is a marked difference between their manners and customs and those of their pagan countrymen.

In 1733, Christian David, Matthew Stach, and Christian Stach, three of the Moravian Brethren, proceeded on a mission to this cold inhospitable country. "There was no need," says one of them, "of much time or expense for our equipment. The congregation consisted chiefly of poor exiles, who had not much to give us, and we ourselves had nothing but the clothes on our backs." No description can equal the difficulties, and dangers, and hardships which the Brethren had to encounter, especially during the first years of their residence in that dreary region. By the Greenlanders they were treated with all the caprice common to savages. Sometimes they appeared very friendly to them; at other times they behaved with the greatest rudeness. If the missionaries stopped with them more than one night, they employed every kind of art to entice them to their wanton dissolute practices; and when they failed in this, they endeavoured to weary and provoke them, by mocking and mimicking their reading, singing, and praying, or by accompanying these sacred exercises with their hideous howling, or the beat of their drums. All this, and much more, the Brethren bore with patience, meekness, and serenity; but the savages, instead of being softened by their gentle behaviour, were only encouraged to abuse them the more. They pelted them with stones, climbed on their shoulders, seized their goods, and shattered them to pieces: they even attempted to spoil their boat, or to drive it out to sea, which would have deprived them of their principal means of subsistence. Cheerless, however, as were the prospects of the Brethren for several years, they at length beheld their labours crowned with remarkable success.

> "Fired with a zeal peculiar, they defy
> The rage and rigour of a polar sky;
> And plant successfully sweet Sharon's rose
> On icy plains, amid eternal snows." COWPER.

In January, 1816, the number of baptized Greenlanders connected with the three settlements which the Brethren have established in Greenland, was as follows:

Begun		
1733,	New Herrnhuth,	359
1758,	Lichtenfels,	306
1774,	Lichtenau,	487
	Total	1152

To some these numbers may appear inconsiderable, but let it be remembered they constitute a large proportion of the Greenland nation. The population of this unhospitable country is said not to exceed six or seven thousand; so that, if this estimate be correct, the Christian converts under the care of the Brethren form about one-sixth of the whole inhabitants of the country. Such indeed has been their success, that in the neighbourhood of New Herrnhuth and Lichtenfels, Greenland has for many years past assumed the aspect of a Christian country. A century ago, not a Christian was to be found in the whole of that unhospitable country; now there are no pagans in the neighbourhood of these two settlements, except occasional visitors. A few years ago only two of the converts at Lichtenfels had relapsed into paganism; and at New Herrnhuth, the number was nearly the same. This certainly is a very extraordinary fact, and is a striking proof of the strictness of the Brethren in the admission of persons to baptism, and of the care with which they afterwards watch over them.

In 1771, the Brethren succeeded in establishing a mission on the unhospitable shores of Labrador, after repeated attempts for this purpose had failed. From their first arrival in the country, the missionaries were treated by the Esquimaux in the most friendly manner, and in a short time the most perfect confidence was established between them. No European would formerly have ventured himself alone with these savages, or have spent a night with them, on any consideration whatever; but the brethren travelled over the ice to them, visited them in their winter-houses, and slept among them many nights successively. When they endeavoured to instruct them in the principles of Christianity, the savages often expressed their astonishment at the things which were told them; at other times they would not listen to any thing about religion. They seemed to have some idea of a Supreme Being, who made the heaven and the earth; yet so feeble was the impression, that there appeared among them no traces of religious worship. To convince them of their sinfulness was no easy task. The liars consoled themselves that they were not thieves; the thieves that they were not murderers; and the murderers that they were not Kablunats, *i. e.* Europeans, to whom it seems they assign the highest place in the scale of criminals.* But though the missionaries for several years met with many difficulties and discouragements, they at length beheld their labours crowned with considerable success. In 1817, the whole number of Esquimaux baptized by them at the different missionary settlements in this country, since the commencement of their labours, was as follows:

Begun	
1771, Nain,	172
1776, Okkak,	244
1782, Hopedale,	185
Total,	601

The schools were attended not only by the children, but by the adults, many of whom made considerable progress in learning. They had family worship both morning and evening in all their houses, and it was extremely pleasing to hear them employed in their own habitations in reading the New Testament, which is now translated into their language, and in singing hymns to the praise of the Redeemer.

After the house of Stuart ascended the throne of England, the tyranny of the government, both in church and state, was so intolerable, that numbers of the people fled from their native land, and sought an asylum in the wilds of America, in the hope of obtaining that liberty of conscience among savages, which was denied them by their own countrymen. In 1646, Mr. John Elliot, one of their ministers, began to preach to the Indians in the neighbourhood of Boston. He afterwards translated the whole Bible into their language, and several other useful books. Besides Mr. Elliot, there were a number of other ministers, who exerted themselves with great energy and zeal in instructing the savages; and their efforts were successful in an eminent degree in promoting Christianity and the arts of civilization among them. In 1687, there were six churches of baptized Indians in New England, and eighteen assemblies of Catechumens professing Christianity. Of the Indians themselves, there were no fewer than twenty-four who were preachers of the gospel, besides four English ministers who preached in the Indian language.

In 1734, Mr. John Serjeant settled as a missionary among a number of Indians on the river Housatunnuk, in the province of Massachusetts. His labours among them appeared at first to be attended with considerable success; but the Dutch traders in the neighbourhood never ceased in their endeavours to corrupt them with rum; and though the Indians passed strong resolutions against drinking, and even kept them for a considerable time, yet some of them unhappily relapsed into that and other vices, even after they seemed to be completely weaned from them. In 1811, the Stockbridge Indians, as they are now called, amounted to 475 persons, none of whom we suppose were professed pagans. Of late years they have made considerable progress in husbandry, and other useful arts.

In 1743, Mr. David Brainerd entered on his labours as a missionary among the Indians. Many were the fatigues, the dangers, and the distresses, which he experienced in the course of his labours among them; and no less singular were the faith, the patience, and the self-denial, which he manifested under trials of this description. His success however amply compensated him for all his toils and sufferings. The impression which his ministrations made upon the Indians was truly extraordinary, yet it was at the same time scriptural and rational. Few men were ever more free from enthusiasm than Mr. Brainerd, and none could be more careful to check it in others. A dry eye was often scarcely to be seen in their assemblies; yet there was no disturbance of the public worship. A deep impression was made on their hearts; but there was no boisterous agitation of their passions. All was powerful and efficacious; yet calm and peaceful. The number whom he baptized was not considerable; but there is reason to believe they were in general sincere converts to the Christian faith.

In 1734, a number of the United Brethren proceeded to North America, with the view of introducing Christianity among some of the Indian tribes. To describe

* To savages, written language must appear a very strange inexplicable thing. Once, when the missionaries read to the Esquimaux a declaration of friendship, by the governor of Newfoundland, they would on no account receive the paper into their hands, from a dread that there was something living in it, which could thus convey to them the thoughts of one who was so far distant, and which might afterwards rise and injure them.

the difficulties, and trials, and persecutions, which they experienced in the prosecution of their disinterested labours, would far exceed the limits of this article. In November, 1755, a party of French Indians arrived in the neighbourhood of the missionary settlement. As the family were one night sitting at supper, they heard an uncommon barking of dogs, upon which one of the brethren went out at the back door to see what was the matter. Hearing the report of a gun, several others ran to open the house-door. Here stood a number of Indians with their pieces pointed to it; and no sooner was it opened, than they instantly fired and killed one of the missionaries. His wife also, and some others, were wounded, but they flew up stairs to the garret with the utmost precipitation, and barricadoed the door with bedsteads. Having pursued them, the savages endeavoured to burst open the door; but being baffled in the attempt, they set the house on fire. Two of the family having got on the flaming roof, leaped down and made their escape. Christian Fabricius, one of the Brethren, was the next who made the attempt, but before he could escape, he was perceived by the savages, and instantly wounded with two balls. He was the only one whom they seized alive; and after dispatching him with their hatchets, they cut off his scalp, and left him dead on the ground. All the others who fled to the garret were burnt to death. Senseman, one of the missionaries who made his escape, had the inexpressible grief to behold his wife perish in this miserable manner. When surrounded by the flames, she was seen standing with folded hands, and in the spirit of a martyr was heard to exclaim, " 'Tis all well, dear Saviour." The whole number who perished in this terrible catastrophe was eleven of the missionary family: five only made their escape. The Brethren, however, were the only sufferers: the Indian congregation happily escaped; but yet they lost the whole of their property, for the savages set fire to the town, and laid waste all their plantations.

During the American war, the missionaries and the Indians under their care were involved in one trouble after another; and toward the close of it, a number of the latter were massacred by the white people, in the most treacherous and cruel manner. The Brethren and their congregation had lately been removed to Sandusky, by Colonel de Peyster, the English governor of Fort Detroit, from the flourishing settlements they had established on the river Muskingum; and, as in consequence of this they were reduced to the greatest straits for want of the necessaries of life, a number of the Christian Indians returned, in order to fetch the corn they had left growing in the fields. While a party of them were in that quarter, a band of Americans came into the neighbourhood, with a design to murder them. After a scene of unparalleled baseness and hypocrisy, they made the Indians prisoners, and told them that they must all die next morning. When the day of execution arrived, the murderers fixed on two houses, one for the men, the other for the women and children, to which they wantonly gave the name of slaughter-houses. These poor innocent creatures, men, women, and children, were bound with ropes, two and two together. They were then led into the slaughter-houses appointed for them. There they were scalped and murdered, in cold blood, by these demons in human form. In this horrid manner perished no fewer than ninety-six persons, among whom were five of the most valuable assistants, and thirty-four children. They behaved, according to the testimony of the murderers themselves, with wonderful patience, and met death with cheerful resignation. The miscreants even acknowledged that they were good Indians, " for," said they, " they sung and prayed to their latest breath." This band of murderers was soon afterwards attacked by a body of English and Indian warriors, and the greater part of them cut in pieces. Thus they met that vengeance from the swords of their enemies, which would probably never have been inflicted on them by the laws of their country: a circumstance in which every heart would exult, were it not for the awful consideration, that persons, whose hands were still reeking with the blood of their murdered victims, were but ill prepared to appear before the tribunal of the Almighty.

By the numerous and heavy trials which it has had to endure, this mission, which was long extremely flourishing, has been greatly checked in its progress. The whole number of Indians baptized by the Brethren, since its commencement, may be estimated, we apprehend, at about 1400; but though they have still three settlements among them, the members of their congregations do not amount to 200.

In 1738, several of the Brethren sailed for Berbice, and settled as missionaries among the Indians. Others afterwards proceeded to Surinam, and established different settlements among those in that colony. Some also went as missionaries among the free negroes; but in consequence of the many difficulties and disasters they met with, they were obliged to relinquish all these undertakings one after another. Among the negro slaves in Paramaribo and the neighbourhood, they were more successful. In 1816, their congregations in this quarter consisted of 817 members.

In Demerara, the Methodist missionaries, and some from the London Missionary Society, have also laboured among the negroes with great success.

In 1732, Leonard Dober and David Nitschman, two of the Moravian Brethren, proceeded to St. Thomas, one of the Danish West India islands. As this was the first mission undertaken by the Brethren, it may not be uninteresting to state the circumstances which gave rise to it, especially as they afford an instance of disinterested benevolence, which perhaps has scarcely a parallel in the annals of history. When Count Zinzendorf was at Copenhagen, attending the coronation of Christian VI. the King of Denmark, a negro, called Anthony, contracted an acquaintance with some of his domestics, and informed them that he had a sister in the island of St. Thomas, who was exceedingly desirous of being instructed in the principles of religion; but as she had neither time nor opportunity for it, she often besought the Great God to send some person to shew her the way to heaven. Anthony having soon after visited Herrnhuth, again declared, in the presence of many of the congregation, the desire of his countrymen, and especially his sister, for Christian instruction; but he added, that the labours of the negroes were so accumulated, that they could have no opportunity of religious improvement, unless their teacher was himself a slave, to instruct them in the midst of their daily avocations. In consequence of this representation, Leonard Dober, and Tobias Leupold, two of the congregation, offered to go to the island of St. Thomas, and to sell themselves as slaves, in case they should find no other way of instructing the negroes. Besides this mission in St. Thomas, the Brethren afterwards established others in St.

Croix, St. Jan, Jamaica, Antigua, Barbadoes, St. Christopher's, and Tobago; but the last has been suspended for some years. In some of these islands, their success has been inconsiderable; but in others, it has been very extensive, as will appear from the following statement of the members of their congregations at the latest period we have been able to ascertain them.

Begun	
1732, St. Thomas	2253
1723, St. Croix	7796
1754, St. Jan	1426
1754. Jamaica, about . .	374
1756, Antigua	7652
1765, Barbadoes, . . .	214
1777, St. Christopher's . .	2240
	21,945

In some of these islands, the success of the Brethren has been so considerable, that the members of their congregations form a large proportion of the whole number of slaves; in St. Thomas and St. Croix, they constitute about one-third, and in St. Jan nearly three-fourths of the negro population. Though the utility of the Brethren's labours are now universally acknowledged, yet we may here mention, that it has been stated on high authority, that, among the planters in the West Indies, a Negro is reckoned doubly valuable if he is a Moravian.

In September, 1786, the Rev. Dr. Coke, accompanied by three other Methodist preachers, destined for Nova Scotia, sailed from England for that country; but the captain was compelled, by stress of weather, to change his course, and to land them on the island of Antigua. Having met with a very favourable reception on that and some other islands which they visited, they resolved, instead of proceeding to the place of their original destination, to attempt the establishment of missions in this quarter of the globe. In the course of a few years, the Methodists accordingly sent missionaries to the principal islands belonging to the crown of Britain; and though, from the great instability which appears among their converts, it is difficult to estimate the extent of their success; yet there can be no doubt that, on the whole, they have been highly useful among the Negroes.

In 1819, the Methodist Societies in the West India islands consisted of the following black and coloured members, exclusive of a few white people.

Begun	
1786, Antigua	3594
1787, St. Vincent's . . .	2685
1787, St. Christopher's . .	2309
1787, St. Eustatia . . .	252
Carry over .	8840
Brought forward .	8840
1788, Barbadoes . . .	26
1788, Dominica . . .	633
1789, Nevis	943
1789, Tortola	1739
1790, Jamaica	5452
1793, Grenada . . .	211
1797, St. Bartholomew's . .	308
1799, Bermuda . . .	44
1800, Bahama Islands . .	516
1809, Trinidad . . .	241
1816, St. Domingo	36
Anguilla and St. Martin .	319
1818, Tobago	17
	19,325

Besides the Negroes and people of Colour who are members of the Methodist Societies in the West Indies, there are 43,411 of the same description of persons connected with those in the United States, making a total of 62,736.

In the West India islands, the missionaries of all denominations have experienced the most violent persecution from numbers of the white inhabitants. Though the Methodists have of late years been the principal objects of this opposition, yet the Moravians, peaceful and prudent as were their endeavours to instruct the Negroes, were long opposed with no less violence. Not only lawless individuals, and infuriated mobs, have frequently assaulted the Methodist Missionaries, and interrupted them in their labours, but the legislatures of several of the islands, particularly Jamaica, have passed severe acts against them, restricting them in their operations, and punishing them by fine, imprisonment, banishment, &c. It will perhaps scarcely be credited, yet the fact is unquestionable, that so late as the year 1792, a British House of Assembly (St. Vincent's) passed a law, inflicting the punishment of DEATH on the score of religion. To what an extent the Methodists were placed beyond the protection of law is evident, from the following notable decision of one of the magistrates of Barbadoes, in the case of a most outrageous assault on their chapel by a lawless mob: "The offence," said he, "was committed against Almighty God. It therefore does not belong to me to punish it." But though the Methodists have experienced the most violent hostility from many of the white inhabitants of the West Indies, it would be an act of gross injustice, both to the planters and to the missionaries, were we not to state, that such sentiments and practices were by no means universal; that though multitudes were their enemies, not a few were their friends and supporters.*

* As the Methodist Missionaries in the West Indies have been grievously calumniated, we think it nothing more than an act of justice to them, to introduce in this place an extract from Watson's able "Defence of the Wesleyan Methodist Missions," which will show very clearly that the hostility to them was far from universal. "A great part of the money," says he, "expended by the West India mission, has been raised in the colonies, of which a considerable sum has been contributed by the whites. There is scarcely a chapel of any magnitude in any of the islands, in the erection of which the gentlemen of the islands have not assisted by their subscriptions or otherwise. They have given money; lent money in considerable sums till it could be conveniently repaid; made presents of timber, or furnished it on long credit; and lent their Negro carpenters and masons *gratis*. Subscriptions of ten, twenty, fifty, and one hundred pounds, for such purposes, mark both the rank in life, and the opinions of the contributors. Even in Jamaica, where the dark and dangerous fanaticism of the Methodists has been discovered with more sagacity than in other places, this assistance has been afforded. The clergy, though not in general personally active in Negro instruction, have given proofs that they are not opposed to the efforts made for that purpose, and that they apprehend no danger from them. It has not been an unusual thing for their slaves to be members of the Methodist Societies by their wish or consent. The rector of Kingston gave £10. 13s. 4d. currency towards the chapel in that city; and on another occasion, £20. towards the Morant Bay Chapel. The rector of

In 1796, the London Missionary Society commenced its operations with a mission to the South Sea islands. Nine of the Missionaries settled in Tongataboo; but a civil war having arisen on the island about two years after their arrival, three of them were murdered by one of the contending parties; and the others, discouraged by the difficulties and dangers of their situation, retired soon after to New South Wales. A solitary missionary, who settled on Santa Christina, one of the Marquesas islands, returned to England at a still earlier period. The others took up their residence in Otaheite, and though they were at first most favourably received by the natives, yet they met with so many difficulties and discouragements in the prosecution of their labours, that this mission, of which the highest anticipations had been formed, was for many years considered as a kind of forlorn hope. The missionaries at length left Otaheite, as a civil war was on the point of breaking out on that island; and most of the friends of missions, we believe, hoped that they would never return, as there appeared not the slightest prospect of their being useful among the natives.

In 1811, several of them, however, did return; but, for the present, they took up their residence in Eimeo, as the continuance of peace in Otaheite was somewhat doubtful. Soon after their arrival, Pomare the king, who used formerly to show a strong aversion to religious instruction, publicly renounced idolatry, and made a profession of Christianity. With him this does not appear to have arisen from political motives; but from the firm conviction of his understanding, and the deep impression which divine truth had made on his heart. The example of Pomare, in embracing Christianity, produced, as might be expected, a powerful sensation among his countrymen. Instructions which had lain dormant, and convictions which had been stifled for years, now appeared to revive. Many of the people began to inquire for themselves; the congregations of the missionaries, which had hitherto been extremely small, rapidly increased; and great numbers publicly renounced the religion of their ancestors. Idolatry was at length completely abolished, both in Otaheite and Eimeo. The gods were destroyed, the morais demolished, the Arreoy Society dissolved, human sacrifices, and the murder of infants, abolished. Instead of a multitude of idols, morais, and altars, there were now Christian churches in every district; except here and there a heap of stones, scarce a vestige of the old religion was to be seen. The Sabbath was observed with singular strictness; family worship was established in almost every house, and secret prayer was the practice of almost every individual. There was at the same time a material improvement in the moral conduct of the people; the condition of the female sex was considerably ameliorated; the population of the islands, which had previously been diminishing with prodigious rapidity, promised soon to increase, as, in consequence of the abolition of infanticide and other criminal practices, there was already a visible difference in the number of children. This extraordinary revolution was not even confined to Otaheite and Eimeo; it extended, in a short time, to the neighbouring islands, Tetaroa, Tapua-Manu, Raiatea, Huaheine, Taha, Borabora, and Marua; in all of which idolatry was abolished, and Christianity became the professed religion. Besides instructing the natives in the principles of Christianity, the missionaries taught them to read and write their own language. In this attempt, they formerly met with little encouragement; now, their exertions were crowned with extraordinary success. In the different islands, it was supposed there were upwards of six thousand persons who were able to read more or less perfectly. Pomare even issued orders that school-houses should be erected in every district of Otaheite and Eimeo, and that the best instructed of the natives should be employed in teaching others; so that these islands now possess something like an establishment of parochial schools. The art of printing has been introduced, and the press is now in active operation in these islands. The gospel of Luke, when printed, was sold for three gallons of cocoa-nut-oil per copy; and though the impression consisted of 3000 copies, yet several thousands of the natives were sadly disappointed that no more were to be had. Had there been 10,000 copies, it was supposed the whole might have been sold in ten days. The plan of selling the books they printed was adopted by the missionaries in preference to distributing them gratis, with the view of promoting industry among the natives.

In 1814, the Church Missionary Society formed an establishment on New Zealand, with the view of introducing the arts of civilization and the light of Christianity among the inhabitants. Hitherto the missionary settlers have been able to effect little; yet their prospects, on the whole, are highly encouraging.

Such is a general sketch of the principal missions established by Protestants in different parts of the heathen world. Many others we have been obliged to pass

Morant Bay also gave £10. towards the chapel in that place; and when a collection was made in the chapel at Kingston, a little before the persecuting law of 1807, for the purpose of affording aid to the building of Morant Bay Chapel, many respectable ladies and gentlemen of the city were present, who put into the box, some joes, and others doubloons, making in the whole a collection of £74. In other islands, not merely planters and merchants, but members of colonial assemblies, presidents, chief judges, and governors, have not only subscribed to the erection of chapels, but in some instances have paid regular stipends to the missionaries, as a remuneration for their labours in instructing their slaves, and in many instances have done what was of more essential service, have counteracted the designs of "wicked and unreasonable men," who attempted to stir up persecutions, for which no pretence but intolerance and misinformation could be set up." P. 125.

After stating some of the causes which had occasioned so much opposition to the Methodist Missionaries in the West Indies, Mr. Watson adds, "Other causes, which have produced many instances of individual opposition to the missions, and which in some cases have chiefly promoted acts of legislative oppression, could be adduced; but we do not seek occasion of crimination, though the causes of opposition we allude to would greatly explain and fix its character."—" If it should appear that the real offence given by missionaries is their preaching faithfully against certain reigning vices; that among the number of those 'turned to righteousness,' have been many females who were the objects of illicit attachment and licentious intercourse; that the personal ill-treatment which the preachers of 'righteousness, and temperance, and a judgment to come,' have in many cases experienced, has been the consequence of violent resentments produced by checks put upon vicious indulgence, by the introduction of a stronger principle of morality among the slaves and females of colour; and that restrictive laws gravely proposed to legislatures have been, in many instances which might be given, mainly the work of men who had such injuries to complain of, then the whole controversy would be placed in a light in which that party are not, we are persuaded, disposed to have it viewed. On this subject evidence is not wanting, but the necessity of adducing it shall be created only by the conduct of those, who are most anxious to justify their zeal against missions on very different reasons." P. 141.

unnoticed, as they were attended with no remarkable circumstances, or were productive of no considerable effects. Should the reader wish more particular details of Protestant missions in general, he may consult Brown's *History of the Propagation of Christianity among the Heathen*, 2 vols. 8vo. 1814. Accounts of particular missions he will find in the following works: Mather's *History of New England;* Mayhew's *Indian Converts;* Hopkin's *Memoirs relating to the Housatunnuk Indians;* Brainerd's *Life;* Niecampii *Historia Missionis Evangelicæ in India Orientali;* Meier *Missions-Geschichte oder Auszug der Evangelischen Missions Berichte aus Ostindien von* 1737 *bis* 1767; *Neure Geschichte der Evangelischten Missions Anstalten in Ostindien* 6. Band. Hans Egede *Nachricht vom Gronlandischen Mission;* Crantz's *History of Greenland*, 2 vols.; Oldendorp's *Geschichte der Mission der Evangelischen Bruder auf St. Thomas, St Croix, und St. Jan.* 2 band.; Loskiel's *History of the Mission of the United Brethren in North America;* Risler *Erzahlungen aus der Geschichte der Bruder Kirche;* Haensel's *Letters on the Nicobar Islands;* Moravian *Periodical Accounts*, 6 vols.; Baptist *Periodical Accounts*, 6 vols.; Coke's *History of the West Indies*, 3 vols.; *Transactions of the Missionary Society*, 4 vols.; *Missionary Register*, 7 vols.; *Proceedings of the Church Missionary Society*, 6 vols. (W. B.)

MISSISSIPPI River. This immense stream, forming a river of the first order, deserves particular notice in an elementary work. Under the general term Mississippi, we include not only that river properly so called, but every secondary, or confluent body of water which enters into, or contributes to augment the mass of the main recipient.*

Following this plan, the basin of the Mississippi may be naturally divided into four grand sections; first, advancing from east to west, the valley of Ohio and its tributary waters; that of Mississippi and its branches; that of Missouri and its branches; and that of the lower Mississippi, below the mouth of Missouri. Of these sections in order.

Ohio valley.—This very important region embraces about 200,000 square miles of area, equal to 128,000,000 of United States acres. Its greatest length is from the north-east sources of the Allegany river to the head of Bear creek, a branch of Tennessee river, 750 miles. Its greatest breadth, from the sources of the French Broad, to those of the Wabash river, 500 miles. In point of climate, it extends from N. Lat. 34° to 42° 30′, or through seven and half degrees of latitude, affording a very considerable difference of seasons and temperature.

It has been long the opinion of the author of this article, an opinion formed from the fruits of many years observation, that the Ohio region once formed an immense inclined plane; and that the beds of all the rivers have been formed by abrasion of water. This theory is supported by Mr. A. Bourne, author of a large and valuable map of the state of Ohio. The following is a quotation from a manuscript letter from that gentleman on the subject. "The hills are generally found near the rivers or large creeks, and parallel to them on each side; having between them the alluvial valley, through which the stream meanders, usually near the middle, but sometimes washes the foot of either hill alternately. Perhaps the best idea of the topography of this state, (OHIO, which see,) by conceiving the state to be one vast elevated plain, near the centre of which the streams rise, and in their course wear down a bed or valley, whose depth is in proportion to their size, or the density of the earth over which they flow. So that our hills, with some few exceptions, are nothing more or less than cliffs or banks made by the action of the streams; and although these cliffs or banks, on the rivers and larger creeks, approach the size of mountains, yet their tops are generally level, being the remains of the ancient plain. In the eastern part of the state, some few hills are found in sharp ridges similar to those in the eastern states. The base of the hills is generally composed of limestone, free, or sandstone, slate, and gravel, admixed with mineral coal, ochre, &c." *Bourne.*

The author of this article surveyed, in 1815, Pittsburg and its environs, and found the rocks there, as in every other part of the Ohio valley, perfectly parallel to the horizon, of course, speaking technically, floetz formation. The circumstance most conclusive of the fact, that the hills and valleys of this region were formed by abrasion, is the uniformity of elevation and similar material, of corresponding strata on the opposing banks of the streams; phenomena every where visible, where the nature of the country will admit accurate observation. The coal strata near Pittsburg are in every place found about 340 feet above low water level in the rivers of that vicinity.

Embracing the whole Ohio valley in one perspective, it is found divided into two very unequal portions by that river; leaving 120,000 square miles to the south-east, and 80,000 on the north-west. The Ohio, forming a common recipient for the water of the minor streams of both slopes, flows in a very deep ravine, S. 64° W., 478 geographical, or 548 miles in a direct line from Pittsburg to the junction of this river with the Mississippi. The entire length of Ohio by its meanders, is by actual admeasurement 948 miles.

The peculiar features of this river, and its immediate banks, have led to most of the gross misrepresentations respecting the valley in general. The low water surface of the Monongahela at Brownsville, has been found to amount to 850 feet above high tide in the Chesapeake bay. Estimating the fall in the Monongahela to be 20 feet from the borough of Brownsville to the city of Pittsburgh, would produce 830 feet as the elevation of the latter place above the Atlantic Ocean. The apex of the hills in the vicinity of Pittsburg, are within a small fraction of 460 feet above the low water level of the Monongahela, Allegany, and Ohio rivers. By these elements we have 460 added to 830, or 1290 feet as the extreme elevation of the hills near Pittsburg above the Atlantic tides. We may, therefore, if the correctness of our previous theory is admitted, suppose, that the latter elevation was that of this part of the original plain from which the valley has been formed. This elevation evidently declined towards the now mouth of the Ohio, leaving a descent for the waters.

* Geographical precision on the subject of rivers, is much enhanced by the use of the terms basin and valley. Basin, denotes the entire space drained by any river; whilst the space watered by a secondary or confluent stream is denominated a valley; thus in the article before us, we have used the term basin, for the entire region from which flows the mass of water contributing to form the Mississippi, and the term valley in describing the various sections which compose this enormous basin.

The actual elevation of the present surface of the country adjacent to the great central junction of the Mississippi, with its confluents, is not determined with the same precision with that of Pittsburg: but, from the length of the Mississippi below the mouth of Ohio, a near approximation may be obtained. From the mouth of Ohio to that of the Mississippi, the distance is within a small fraction of 1100 miles, which, at 3½ inches to the mile yields 3850 inches, or 320.8 feet, as the entire depression of the Mississippi river, from the mouth of Ohio to the Gulf of Mexico.

The fall in the Ohio river exceeds that of the Mississippi, and has been estimated at about 5 inches to the mile, consequently, if we multiply 948 miles, the entire length of Ohio, by 5, we have 4740 inches, or 395 feet, as the amount of descent in that stream; and, adding 395 to 320.8 feet, we find 715.8 feet as the declivity of the waters from the confluence of the Monongahela and Allegany rivers at the city of Pittsburg, to the Gulf of Mexico.

A very remarkable difference is perceptible between the different elevations of Pittsburg above the Chesapeake Bay and Gulf of Mexico, amounting to more than 125 feet, in favour of the former sheet of water. This apparent phenomenon is explicable on the simplest laws of hydrostatics. The Gulf stream flows from the Gulf of Mexico towards that part of the Atlantic Ocean adjacent to the Chesapeake Bay, demonstrating that a difference of level must exist between the extremes, sufficiently great to admit a current of considerable velocity. That velocity has never been very accurately determined; but, if we allow only 1½ inch per mile, would yield in 900 miles 112½ feet. That the actual fall from Florida channel to the mouth of the Chesapeake Bay, considerably exceeds 100 feet, there can be no rational doubt, when the necessary geographical phenomena are duly examined.

We may, from the data given, consider the valley of Ohio composed of an inclined plane, chequered by the deep channels of the rivers, hills, and extensive flats, the whole resting upon a base of secondary formation. In many parts of this interesting region, as in the state of Kentucky, the beds of the rivers are vast chasms, rather than valleys, in the true acceptation of the latter term. The two opposing slopes exhibit some very curious contrasts. Though considerably most extensive, the south-eastern slope has no extensive remains of the ancient plane; the north-western slope, on the contrary, contains immense remains of the former plane. The rivers which enter the main recipient from the former, rising in or near the north-western ridge of the Appalachian Mountains, are precipitous from their sources, flowing, as already observed, in very deep channels: whilst those streams which enter from the north-western slope, rise out of a level continuous plain, in many places morass, as in part of the states of Ohio and Indiana. The latter rivers are sluggish towards their sources, gaining velocity in their advance towards the Ohio river.

The secondary rivers of the south-eastern slope, are, the Monongahela, Little Kenhawa, Great Kenhawa, Sandy, Licking, Kentucky, Greene, Cumberland, and Tennessee. Those flowing from the north-western slope, are, the Allegany, Beaver, Muskingum, Hockhocking, Sciota, Miami, and Wabash. Of these streams, the Allegany rises in Pennsylvania, flows into New-York, and winding from north-west to west, and south-west, again enters Pennsylvania, forming the north-western, or rather northern constituent of Ohio. No branch of the Allegany flows from the high table land; the region it waters is in some parts mountainous, and every where hilly; the sources of the Allegany flow, however, from the highest point of the valley of Ohio. Advancing westward from the region watered by the Allegany, the sources of the Beaver exhibit the commencement of the great central plain, which separates the two great basins of the Mississippi and St. Lawrence. This plain stretches westward, and, widening in extent through the states of Ohio, Indiana, and Illinois, reaches the Mississippi river. In its natural state, the valley of Ohio was, in the greatest part of its extent, covered by a dense forest: but the central plain presented a very remarkable exception. As far east as the sources of Muskingum, commenced open savannahs, covered with grass, and devoid of timber. Similar to the plain itself, those savannahs expanded to the westward, and on the waters of Illinois river opened into immense natural meadows, generally known under the denomination of prairies.*

We have dwelt with more minuteness on this central plain than we would otherwise have done, from a conviction that it affords phenomena highly illustrative of the peculiar structure of that part of North America. It has been shown in this article, that the surface of Ohio, at the city of Pittsburg, was 830 feet above the nearest tide water of the Atlantic Ocean, and 715.8 feet above the surface of the gulf of Mexico. Lake Erie has been found, by actual and careful admeasurement, 565 feet above the tide water of the Hudson at Albany; consequently, the Ohio at Pittsburg is 265 feet above the surface of Lake Erie; the intermediate distance, in a direct line, 105 miles. Therefore, if a channel was open from the Ohio river at Pittsburg to Lake Erie, as deep as the bottom of the river, and sloping towards the lake by gradual descent to its surface, the waters of Allegany and Monongahela would, in place of flowing down Ohio, rush into Lake Erie with the enormous velocity arising from a fall of 265 feet in 105 miles; or upwards of 2½ feet per mile. When these mathematically established facts are contrasted with the circumstance, that the extreme north-western waters of Allegany, those of Lake Chataughque, rise within three miles from Lake Erie, the singular but real construction of the country becomes apparent. Nothing but actual measurement could render credible, that Pittsburg, situated at the confluence of two streams, each of which, following their meanders, have flown above 200 miles; and one of which, (Allegany,) having part of its source so near the very margin of Lake Erie; and yet, that the city of Pittsburg should be elevated 265 feet above the surface of the lake.

But by far the most remarkable feature of the Ohio valley is, that its real slope does not correspond to the courses of its rivers. It is a fact now well known, that loaded boats at high water can pass from Lake Michigan into Illinois river, and vice versa. We have seen that Lake Erie was 565 feet above the level of the Atlantic tides. The elevation of Lake Michigan above Lake Erie cannot, from the shortness and gentle currents of Detroit river, St. Clair river, and the straits of Michilimachinak, exceed 35 feet. We may therefore assume 600 feet as the level of Lake Michigan. This would correspond very nearly with that of the Ohio river, between the

* Prairie is a French noun, literally translated meadow.

mouths of Miami and Kentucky rivers. Illinois river we will see, presents much more the aspect of a canal than that of a river, whilst the central table land we have reviewed, is so elevated, as to produce water-courses, whose descent is rapid, and those flowing into Lake Erie all precipitated over falls before reaching their recipient. During the continuance of spring floods, loaded boats of large tonnage may be navigated from the rapids of Ohio, by that river, the Mississippi and Illinois rivers, and through the Canadian sea to the cataract of Niagara, without meeting a single rapid; whilst the direct line between the extremes of this navigation, would pass over an elevated ridge. When due attention is paid to the real phenomena of the connected basins of Mississippi and St. Lawrence, the true causes of the apparent anomalies we have noticed are developed. It is at once rendered apparent, that the true slope of the Ohio valley is nearly at right angles to the range of the Appalachian mountains, and that its lowest line of depression, is the channels of the Illinois and Mississippi rivers.

Soil, climate, and productions.—The soil of this interesting section of the earth, is by no means so uniform as is generally supposed, though taken as a whole, may be considered fertile. The alluvial bottoms of the streams, great and small, are generally a deep loam, exuberantly productive. This rich vegetable earth, in many places reaches the apex of the highest hills. Those hills present, however, great variety of soil; always clothed with timber, though often precipitous, rocky, and sterile. The extreme south-eastern part, from the sources of Allegany to the most southern part of the valley in the state of Alabama, presents a mountainous or very broken hilly tract of country, upwards of 700 miles in length, with a mean width of about 100. The soil is on this region extremely varied, and as it contains at its extremities nearly the greatest contrast of latitude of the valley of which it forms a part, the vegetable productions, natural and artificial, are here also most varied. Very few timber trees, known on this continent between N. Lat. 34 and 42 degrees, but which are here found. The most prominent and valuable species of which, are ten or twelve species of oak; hemlock, pine, the Liriodendron tulipifera; five or six species of hickory and walnut; three species of maple, one of which, the Acer saccharinum, is amongst the most singular and valuable trees known on this globe; three or four species of ash, with an immense variety of useful trees and shrubs not enumerated. The Flora is also highly varied and elegant. Medicinal plants abound. Spring water is abundant and excellent.

Of naturalized plants, trees, and shrubs, the number and variety preclude a complete specification. Extending through eight degrees of latitude, and presenting considerable difference of level, the climates admit the cultivation of plants whose powers of resisting the inclemencies, or of profiting by the changes of seasons, are very different. The cereal gramina—wheat, rye, oats, barley, and Indian corn or maize, is every where cultivated. Meadow grasses flourish best in an advance to the north. In the southern part, even where extensive settlements have been made, meadows are rare; but towards the northward, form a large part of rural economy. This observation, though in a more limited extent, may be applied to orchards, and even gardens. Where the crops become very valuable, horticulture is every where neglected, as are orchards, except in the vicinity of cities or large towns. In the region before us, below N. Lat. 36° 30′, cotton commences to be cultivated as a valuable crop. Some culture of this vegetable extends north of the assumed limit, but rather for domestic use than as an article of commerce. The quantity and quality of this vegetable is enhanced, soil and exposure being equal, in a very near ratio, with advance to the south. As we will have more occasion to dilate on this vegetable in the sequel of this article, it would be irrelevant to touch farther on the subject in this place.

The orchard trees generally cultivated in the region before us, are the apple, pear, peach, plum, nectarine, &c.

The mineral treasures of this region compose a large share of its most valuable productions. Iron, salt, and mineral coal, are the most valuable and abundant. Iron ore is found in almost every section of this extensive line. The immense masses of mineral coal are very extensive: those near Pittsburg are only the most abundant and best known. It is amongst the most remarkable features in the natural history of the United States, that from Onondago in the state of New-York, to the south-west angle of Virginia, the earth appears in every place, at a certain depth, to afford water saturated with *muriate of soda*, (common salt.) This indispensable mineral is found where, if wanting, it could not be obtained without very great expense. Salt is now made at Onondago in New-York, Conemaugh in Pennsylvania, and on the Kenhawa and other places in Virginia;—all in the same range.

The Ohio river bounds the tract we have reviewed as far southward as the mouth of the Great Sandy. Here the former turns almost at right angles, and pursuing a course something north of west to the mouth of the Great Miami, again inflects about south west by west to its junction with the Mississippi. This wide curve, in conjunction with a part of the Mississippi, bounds the great limestone expanse of Kentucky and West Tennessee. This latter region, though adjoining the former, presents features essentially different. The base of the Kentucky section appears to be in great part flœtz or secondary limestone, the face of the earth becomes more monotonous; the rivers flow in many places in chasms, walled on both banks by precipices of limestone. Fresh water in many places scarce. Minerals rare, if limestone is excepted. In point of climate and vegetable production, no very material difference appears between the contiguous parts of the two sections under review, except that which arises from soil. In point of extent and fertility, the soil of Kentucky and West Tennessee is generally productive, and in a variety of places highly fertile. Vegetables, either indigenous or exotic, are very nearly, on both sections, on a similar line of latitude, and of equal exposure and elevation. From a lower surface, cotton, and other tender vegetables, are cultivated farther north, near the Ohio, than towards the north-western ridges of the Appalachian mountains. The climate of both will be more amply noticed in the sequel of this article.

Respecting the north-western section of the Ohio valley, a few observations will suffice, after what has preceded respecting that of the south-east, and on the review of the whole valley in general. Similar latitudes present in great part similar climatic phenomena and vegetable products. From the peculiar structure of the north-western section already delineated, it must be evident that mineral products are rare; and such is the fact. Iron ore is found, though not abundantly, in the north-west part of

Pennsylvania, and north-east part of Ohio. Mineral coal abounds along the Ohio, and on some other streams, as far down the valley as Cincinnati, and might, it is probable, be obtained in other places, if the earth was perforated to sufficient depth. Indications of muriate of soda, and some trifling fragments of sulphate of lime, (Gypsum,) have been discovered, but neither to any considerable extent. In the far greater part, however, of this section of the Ohio valley, few or no indications of minerals appear. The flatness and peculiar structure of the two-thirds of the states of Ohio, Indiana, and Illinois, preclude the exposure of mineral bodies, if such existed. It has been by the action of water in wearing deep channels in the earth's surface, that mineral bodies have, in most cases, been exposed to human view and use.

In point of soil, climate, and vegetable production, the south-western section of the Ohio valley has been too highly coloured, though favourable in many respects to human residence. The range of country within one hundred miles of the Ohio river being broken into hill and dale, good wholesome water is abundant, but receding to the central table land, is in many places wanting. In most essential circumstances, as respects natural phenomena and human economy, strong analogies exist between the contiguous parts of the two great sections of Ohio valley, whilst their extremes present a total contrast. It would be mere repetition to dilate further, after what has been given on this subject; the foregoing observation was made in order to draw the reader's attention to features so strongly traced, and illustrative of the subject on which we are treating. It has been too generally prevalent with authors, as well as travellers, to respresent the Ohio valley as a monotonous surface, uniform in aspect, climate, and fertility; whilst, in all these respects, perhaps no equal region of the earth presents, in all these points, more marked or more abrupt contrasts, if some very mountainous tracts are excepted.

Valley of the Mississippi Proper.—Before entering upon the physical survey of the particular valley of the Mississippi, above its junction with Missouri, it is necessary to take a view of the entire stream which now designates the whole basin.

In our defective state of information, it is impracticable to determine which is the most remote branch of the Mississippi, nor is it perhaps an object of much consequence. The latitude and longitude of its source are also undefined. Authorities on that subject differ so much, that no great confidence is due to any. It is probable, that like other rivers, no real certainty of the main source or latitude is attainable without extraordinary pains and skill. We may, however, assume N. Lat. 48°, and W. Long. from Washington city 18°, as the source of that great river. Its general course is about south-west 300 miles, to the mouth of the Corbeau, which comes in from the right. Below the Corbeau, the Mississippi assumes a south-eastern course of 200 miles to St. Anthony's Falls, at the foot of which it receives the St. Peter's, a large tributary stream from the north-west. Below the mouth of St. Peter's, the Mississippi continues south-east 80 miles, and in that distance receives from the left the St. Croix, Chippeway, and Black rivers. Between the two former occurs Lake Pepin, a mere dilatation of the river. After receiving Black river, the Mississippi curves more to the south, and 80 miles below the former, receives from the left a large branch, the Ouisconsin. Thence again turning to south-east 100 miles, is joined by Rock river, a stream of considerable size, flowing from north-east to south-west, and rising near Lake Michigan. Below Rock river, the Mississippi turns to a little west of south, 100 miles, to its junction with the Lemoine river, a very considerable tributary stream from the north-west. One hundred and twenty miles, in a south-eastern course, below the Lemoine, the Illinois unites with the Mississippi, and 15 miles lower, the latter and Missouri form their junction. The entire length of the Mississippi above the mouth of Missouri, is by comparative estimates, 995 miles. The country drained by this river is generally rather level than hilly, much of its surface prairie. Except towards its source, no lakes of any considerable consequence are found on any of its confluents. Its water is tolerably limpid, and its current gentle. Though, from accidental circumstances, the Mississippi has gained the pre-eminence in giving name to the general recipient, it is, nevertheless, a mere branch, and by no means the principal one, of Missouri. Below their junction, the united stream flows 198 miles south-east, where it receives an immense accession of water through the channel of Ohio; below which, the congregated mass turns a little west of south, and flows in that direction 316 miles, receives the White river, and 14 miles lower the Arkansaw; both from the right. The Yazoo enters from the left, 187 miles below the mouth of Arkansaw; and 211 miles below the mouth of Yazoo, the Mississippi receives its last tributary stream of consequence, the Red river, from the right. Two miles below Red river, the Atchafalaya flows out to the south. From the mouth of Arkansaw to the efflux of Atchafalaya, the general course of the Mississippi is nearly from north to south. Below the former, the latter assumes a south-east course, which it pursues 347 miles, to its final exit into the Gulf of Mexico. The entire length of the Mississippi, below the mouth of Missouri, is 1273 miles, by the windings of the stream. If one-third is added to its comparative length above Missouri, for its particular meanders, the result will give 1327 miles, which added to 1273, yields 2500 miles, as the entire length of the Mississippi, following the bends.

Like all rivers of great length, the Mississippi is subject to an annual rise and fall. The periods of those floods are tolerably regular, but the quantity and elevation of the water differs continually, and often to many feet in two succeeding seasons. The river commences its swell generally in March, or the beginning of April. The increase of the water, at first rapid, gradually becomes more slow, until the supply beginning to exhaust, the volume commences its fall or decrease, which, at Natchez, is in a long series of years, from the 15th to the 20th of June, and, at New Orleans, in the first week of July. There is, however, in most years, a lesser and earlier flood, which varies in time, much more than that of the spring and summer. In October, November, or December, this lesser flood intervenes generally, in the last days of December, and first of January. This lesser flood seldom rises so high as to overflow the banks, and it has been observed, that when the earlier flood is more than commonly high, that the later flood is in proportion, lower than common. The efflux of Plaquemine, is the common scale in the Delta of the excess and period of both floods; which article see.

The velocity of the current of the Mississippi has been greatly mistaken. Taking the motion of its swells, the only safe criterion, it is found that, below Ohio, the entire mass does not move as much as one mile per hour. The line of upper current moves more rapidly than the mass, but even the former does not move by any means with the rapidity usually supposed. This subject will be more amply explained under the head of *Rivers*, which see.

The depth of water in the Mississippi varies of course with the increase and decrease of its floods, but this difference of elevation is more perceptible above, than in the Delta. At Natchez it is from 30 to 40 feet, at Lafourche about 23 feet, and at New Orleans about 9 feet. There is usually about 12 feet water on the bars of the North-east and South-west Passes. In the South and West Passes 9 feet, and in those of the North and Pass à la Loutre 8 feet. Above the passes, the river deepens to upwards of 100 feet. At New Orleans it is upwards of 120, and at the Lafourche 153 feet at high water. There is no place below the mouth of Ohio, where the channel is ever less than 12 feet in depth.

Valley of the Mississippi proper; above the mouth of Missouri.—In point of area, the valley of the Mississippi proper is not so extensive as that of Ohio, the former only extending over a surface of 180,000 square miles. Its greatest length is from the sources of the Mississippi river to the junction of that stream with the Missouri, 650 miles, and its greatest breadth from the sources of the Ouisconsin to those of Lemoine river, 350 miles.

Before proceeding farther, however, with the descriptive geographical detail, it may not be considered irrelevant, to review one of those great natural features of North America; without attention to which, no correct conception of its peculiar topography can be obtained. This feature is the great natural meadows, known by the name of Prairie. In a state of nature, with but very partial exceptions, a dense forest covered all those parts of the continent of North America contained in the Atlantic slope; the lower part of the basin of St. Lawrence, below the head of Lake Erie, and two-thirds of that basin to its extreme north-western point; north of the St. Lawrence basin to the 55th degree of N. Lat.; four-fifths of the valley of Ohio; the residue of the continent east of the Mississippi river to the Gulf of Mexico; and west of that stream from 50 to 100 miles. This enormous forest, one of the largest on the globe, remains yet nineteen parts in twenty;—the efforts of man having made but partial inroads on either its mass or extent. This great forest is bounded on its western limit by another region of much greater area, but with a very different character. The second may be strictly called the grassy section of the continent of North America, which, from all that is correctly known, stretches from the forest region indefinitely westward, and from the Gulf of Mexico, to the farthest Arctic limits of the continent. The two regions are not divided by a determinate limit. In passing from one to the other, the features respectively are so blended, that the change is in most places imperceptible; though in some instances extremely abrupt.

In general, the prairie region is less hilly, mountainous, or rocky, than that of the forest; but exceptions in both cases are frequent. Plains of great extent exist in the latter, and mountains of no trifling elevation and mass chequer the former section. We are now to approach the survey of regions in which prairie forms no small part of the entire surface, and will in the sequel reach others, where those seas of grass extend over almost the whole superficies.

The extreme northern source of the Mississippi, strange as it may appear, continues unknown. In Melish's map, it is laid down at Turtle lake, 47° 46′ N. Lat., whilst in Schoolcraft's Map, lately published, the sources of that great river are extended to the Lakes Labeish and Turtle, both extending above N. Lat. 49°: a discrepancy between these two authorities of course exists of 1° 14′ of Lat. The nature of the country, indeed, renders precision on this point difficult, without extreme expense of labour and time. We will assume N. Lat. 48° as the source of this great river; its junction with Missouri being at N. Lat. 38° 56′, it flows consequently through nine degrees of latitude, within a trifling fraction. The length of the Mississippi above the mouth of Missouri, is still less accurately known than the position of its source, every authority differing from each other on the former subject. That nearly all estimates of its length are overrated, there are many weighty reasons to believe. Compared with the Ohio, on most maps, no essential difference appears, when the Allegany is added to the latter. The actual length of the Ohio, by its meanders, we have shewn to be 948 miles, that of the Allegany is about 250; the two distances united amount to 1198, say 1200 miles. For a long period, the Ohio itself was estimated at 1188: more correct information corrected the error. On all maps, and from every information we have seen, the sinuosities of the Ohio are at least as great as that of the Mississippi; we may, therefore, without much risk of material error, give 1327 miles as the maximum length of the latter stream.

The confluent rivers of the Mississippi, advancing from its source along its right bank, are, Leech Lake river, Vermillion, Pine river, Riviere de Corbeau, Elk, Sac, and Crow rivers: these enter above the falls of St. Anthony; below that point are, St. Peter's, Upper Jowa, Turkey, Little Maquauquetois, Galena, Great Maquauquetois, Lower Jowa, Lemoine, and a few other streams of little note between the mouth of Lemoine and that of Missouri. From the left the Mississippi receives, advancing from its source, Thomberry river, Round Lake river, Turtle Portage river, Chevreuil, Prairie, Trout, Sandy Lake river, St. Francis, and Rum rivers. These streams enter above the Falls of St. Anthony. Below that point are, St. Croix, Chippeway, Black, Prairie la Crosse, Ouisconsin, Sissinawa, Riviere au Fevre, Rock, Henderson's, and the Illinois. These streams are given, in most part, from the authority of Mr. Schoolcraft, and are also more minutely detailed, from the circumstances that the valley of the Mississippi proper is yet imperfectly known, of great importance in the geography of the United States, and that the source of intelligence is recent and respectable.

Mr. Schoolcraft estimates the elevation of the sources of the Mississippi at 1330 feet above the Atlantic.* From comparison with our own calculations respecting

* Taking the elevation of Lake Erie, as determined by the actual survey of the New York commissioners, for a basis, we find the surface of Lake Superior to be 641 feet above the Atlantic Ocean. From the head of this lake, following up the St Louis river to the Savannah Portage, and from thence across the dividing ground, to the spot where we first strike the waters of the Mississippi, at the head of the west savannah, the aggregate elevation, at 550 feet. The descent of this stream into Sandy Lake, and from thence into the Mississippi river, will reduce this estimate by the sum of 60 feet. From the junction of Sandy Lake river, to the principal source of the Mississippi in Cassina Lake, we attain an elevation of 162 feet, which, superadded to the former estimates, shews the Mississippi river to originate at an elevation of 1330 feet.—*Schoolcraft's Narrative of the Expedition under Governor Cass, page* 261.

the descent of the Ohio, a very remarkable coincidence appears though founded upon totally independent data.

The valley of the Mississppi, though contiguous to that of Ohio, exhibits an aspect essentially different. The sources of the latter we have found issuing from an elevated, mountainous, hilly, and broken country; those of the former, on the contrary, flow from an immense marshy plain, in great part devoid of timber. The humble elevation of the region from which the sources of the Mississippi are drawn, accounts for the adjacent country remaining in its primitive state, and fully corroborates the correctness of the theory assumed respecting the valley of Ohio.

One of the first observations which strikes the mind on a survey of this extensive tract, is, its general monotony. No chains of mountains of note, or even lofty hills rise to vary the perspective. Some elevations there are towards the sources of the largest confluents, and a few solitary hills, dignified, for want of contrast, by the title of mountains. The Mississippi is traversed by several falls, such as those of Pecagama, about midway between Sandy and Winnepec lakes, at N. Lat. 47° 30′; the Little Falls, at N. Lat. 45°; the Big Falls, below the mouth of the Sac river; and those of St. Anthony, at N. Lat. 44°, immediately above the mouth of St. Peter's river. The view of extensive prairies, when first seen, have an awful and imposing effect on the mind, but that impression is soon lost, and a dreary void obtrudes in its place. Many parts of the Mississippi banks are high, broken, and precipitous; but taken as a whole, this great valley presents few objects upon which those can dwell with interest who pass from the rich ever varying scenery of Ohio; particularly that of its banks and south-eastern slope.

Had the head waters of the Mississippi descended from a mountainous, or even a very high table land, similar to that from which flows the Ohio, with a slope of sufficient inclination, the general face of the country, drained by the former river, would have now assumed an aspect similar to that from which flow the head waters of the latter. But in reality, though on a much larger scale, the Mississippi resembles those of the north-west slope of Ohio valley, in the circumstance of flowing from a flat table land, and in gaining ascent and depth of channel in their progress towards their respective recipients. It is a feature peculiar perhaps to the Mississippi, that the country adjacent to its source and that near its final discharge, are in so great a degree similar in their general physiognomy. A difference of latitude of nineteen degrees precludes much resemblance in vegetable or stationary animal production. But according to Mr. Schoolcraft, who visited its sources in the month of July, the migratory water fowl found there at that time of the year are very nearly specifically the same found at its mouth in the months of December, January, February, and March. "It is also deserving of remark," says that writer, "that its sources lie in a region of almost continual winter, while it enters the ocean under the latitude of perpetual verdure."

Climate, Soil, and Production.—Extending through nine degrees of latitude, the change of climate in the valley of the Mississippi proper, is greater than found in any other valley in the basin of which it forms a part, except the more northern parts of that of Missouri. So defective is our information respecting the larger tributaries which enter the Mississippi above Missouri, that little more need be added respecting the Mississippi valley in general. Suffice to say, that in point of soil, vegetable and mineral productions, (lead excepted,) this valley is in every respect inferior to that of Ohio. The ordinary timber in similar latitudes are nearly the same in both valleys; but towards the sources of the Mississippi, pine, spruce, cedar, maple, and white birch are the prevalent timber trees. In fact, the far greater part of the upper, and much of the lower part of the valley, is composed of prairie, low swamp, or lakes. Much good alluvial land, particularly on the Illinois, borders the streams, but in no moderate proportion to what is found in the valley of Ohio.

In the lower part of the Mississippi valley the exotic vegetables cultivated are, in most part, the same found in our middle states generally. The climate being rather more severe in a given latitude in the Mississippi basin than on the southeast side of the Appalachian mountains, some small difference of vegetable location may exist, but not to any very great amount.

Towards the sources of the Mississippi, the wild rice (zizania aquatica) abound in the swamps, and along the low margins of the rivers and lakes, and constitutes no small part of the food of the natives. Perhaps in an advanced state of society, this species of cerealia, which can be cultivated in places unsuitable to any other vegetable, may become the resource of civilized man, and under skilful culture attain a development similar to what has taken place with other grains, such as wheat, rye, oats, barley, and maize. In fine, in the valley of the Mississippi, we find every object denoting our approach to the wide spreading waste on which we are now to enter.

Valley of Missouri, above its junction with the Mississippi.—The Mississippi having been first discovered, has by prescription given name to the whole basin; but the Missouri, above their junction, is a stream which has drained a country of more than six times the extent of the valley of the former. The error is now without remedy; therefore, though of so much greater magnitude, must, in a geographical point of view, be considered a tributary stream to the Mississippi.

Missouri river rises in the Chippewan, or, as they are absurdly called, Rocky Mountains. What is by preeminence called Missouri, is not the main stream, if our maps are even tolerably correct. The Yellow Stone river is longer than its rival above their junction, and receives larger and longer tributary streams. Assuming, however, Jefferson's river as the extreme source of Missouri, the latter will rise at N. Lat. 44° 20′ W. Long. from Washington City 35°. The general course for about 120 miles is north-east, receiving in that distance several tributary streams. It thence turns north 120 miles, and about N. Lat. 46° 20′, is augmented by Dearborne's river from the north-west. It thence curves to the north-east 80 miles, to the entrance of Marias river from the north-west. Below its junction with the Marias river, the Missouri pursues an eastern course 150 miles, and thence a north-eastern course of 150 miles to the mouth of Yellow Stone river. Estimating the distance from its source by either branch, along the stream, the Missouri has flowed, at its junction with Yellow Stone river, more than 1000 miles, and has drained above 150,000 square miles of surface, mostly prairie. Its volume is here, perhaps, as wide and deep as at its junction with the Mississippi. After receiving the Yellow Stone, the Missouri curves first north-east, and thence south-east, 200 miles, to the Mandan villages, at N. Lat. 47° 25′. Between the mouth of Yellow Stone river and the Mandan villages, the volume of Missouri has gained its extreme north bend at N. Lat. 48° 20′, and has, besides many lesser tributaries, received the Little Missouri from the right, flowing from south-west to north-east. Nearly opposite to the mouth of the latter, the Moose river branch of Assiniboin rises within less than one mile from the bank of the Missouri. At the Mandan villages, the Missouri turns directly south, and flows in that course through four degrees and twenty minutes of latitude, or near 300 miles. In this distance it has received a few unimportant tributaries from the left, and from the right the large streams of Cannon Ball, Wetarhoo, Sarwarcarna, Chayenne, Teton, and White rivers. Below the mouth of the latter, the Missouri turns to the south-east, east, and south, 300 miles, to its junction with the La Platte, an immense body of water flowing from the west, and heading with the Arkansaw, Lewis's, and Yellow Stone rivers. In the latter course, the Missouri has also received from the left the Jacques, Great, and Little Sioux rivers. Below its junction with the Platte, the Missouri flows 200 miles south-east to the mouth of the Kanses river, a large tributary flowing from the west, and heading between the Arkansaw and Platte rivers. The Missouri has now gained nearly the 39th degree of north latitude, and turning to a little south of east 250 miles, joins its vast volume to that of the Mississippi, after an entire comparative course of 1870 miles, and particular course of about 3000 miles. Between the mouths of the Kanses and Mississippi rivers, the Osage, a large branch, enters Missouri from the south west. The Osage is a considerable stream, rising in the angle between the Kanses, White, and Arkansaw rivers.

Our geographical knowledge of the various branches of Missouri, is still more limited than respecting the Mississippi. Of the main stream, as high as the Mandan villages, our notices are tolerably ample. Lewis and Clarke, Stoddard, Brackenridge, Bradbury, and others, have enlarged the public stock of information on this interesting topic: but with all that has yet been published, a feeble light has been thrown upon those immense regions.

The greatest length of the basin of Missouri, is from the mouth of that stream to the head of Marias river, 1200 miles; its greatest breadth, from the sources of the Platte to a few miles south-east of the Mandan villages, 700 miles. The outline is too vaguely known to admit precision, as to the area of this vast extent; it must, however, equal, if not exceed 500,000 square milles, equal to 320,000,000 United States' acres.

General features.—Engrasping the whole valley of Missouri in one view, two remarkable features must command pre-eminence; the turbid muddy appearance of the water, and the very great difference in length and volume of the confluent streams from the right bank, when compared with those from the left bank of the main recipient. Whilst from the right, the Missouri receives such vast branches as the Yellow Stone, Chayenne, Quicourre, Platte, Kanses, and Osage; from the left, all the branches are of minor importance. This characteristic continues to distinguish the valley of the lower Mississippi below the mouth of Ohio; where, to the vast volumes of the White, Arkansaw, and Red rivers, are opposed the very inferior streams, the Yazoo, Big Black, and Homochitto.

It would appear that the Mississippi basin is divided into two immense inclined planes, falling from the two opposing chains of mountains, that of the Chippewan, and the Appalachian; and that the two planes are in a very near ratio to the respective magnitude and elevation of the chains from which they decline. The line of contact between those planes is formed by the Illinois. and thence by the Mississippi, below the mouth of the former; and if we extend our views beyond the Mississippi basin, Lake Michigan is evidently the continuation of this line of depression to the north; whilst to the south-east, the rivers entering the gulf of Mexico, as far as the Appalachicola inclusive, belong to the Appalachian plane; and to the south-west, all streams flowing into the gulf of Mexico, as far the Rio Grande del Norte inclusive, appertain to the plane of the Chippewan.

But to return to our particular subject, that of the Missouri valley. It would be useless to give a list of the smaller rivers of this tract, the names of which are hardly known. A general outline is all that ought to be attempted. The Missouri valley is bounded on the west by the enormous chain of the Chippewan or Rocky mountains, from which flow the sources of the Missouri and most of its largest branches. The exact elevation of the Chippewan, or indeed any of its peaks within the domain of the United States, have never been determined, and the result made public. The general table land upon which those ridges rest must from the great length of the Missouri exceed 3000 feet; perhaps about 5000 feet would be a safe estimate for the gneral elevation of the whole chain, particular peaks excepted.

The Chippewan partakes with the adjacent country the character of nakedness, timber being rare and of stunted growth. Like the Appalachian, and most other American mountains, the Chippewan is formed in collateral ridges, with deep intervening valleys. The rivers rise in these valleys and pierce the ridges in their course. The sources of Missouri extend along the chain through near eight degrees of latitude, or upwards of 500 miles. In this region the main stream and most of its tributaries flow to north-east. The sources of Big Horn, a branch of the Yellow Stone river, rise at N. Lat. 41° 30′, whilst Marias river has its most northern source above N. lat. 48° 30′. Some of the northern confluents of Missouri probably lie as far as N. lat. 50.

Missouri leaves the Chippewan by falling over continued ledges of rocks, in a distance of 18 miles; after which, this overwhelming mass of water is augmented every few miles by large tributary waters, without falls or even shoals to its mouth. The channel is deep, and bounded by enormous precipices of rock. The immediate margin of the streams only excepted, this almost interminable expanse is priarie, devoid of timber; and except the deserts of Arabia, no part of the earth presents an equal surface, less inviting to civilized man, than the far greater part of the valley of Missouri. Its asperities become more apparentas information respecting its real features expand. The general character of this extensive valley may be completed in few words; that, with some very partial exceptions, it is a wide and arid waste in summer, and over which in winter, the piercing winds of the north sweep without impediment, and on which a dense civilized population can never exist.

Climate, Soil, and Productions.—In so wide an extent a very great diversity of climate must necessarily exist. From the considerable elevation of some parts, northern position of others, and the open exposure of nearly the whole extent, the winters are extremely severe. The whole of the valley, a small part of the south-eastern extremity excepted, has an aspect and climate with a striking resemblance to the steppes of central Asia; and, like those steppes, must for ever be thinly peopled.

With the exception of the alluvial banks of the streams, the soil is, as far as correct information has been obtained, dry and sterile, which, added to the want of timber, and in many places of great extent, water, settlement of an agricultural people is rendered not only difficult but impossible.

The state of Missouri, embracing about 63,000 square miles, it is probable, if the advantages of climate are superadded to soil, possesses one fourth part of the productive surface of this entire valley.

Of the indigenous vegetables of the Missouri valley little can be said. Mr. Bradbury was the only naturalist of sufficient skill to investigate the subject of its botany, who ever reached the interior of the valley, as far as the Mandan villages, and his opportunities of observation were so limited as to preclude extensive research.

Of the timber trees and exotic plants, we will have an opportunity to speak under the article, State of Missouri, (which see.)

It is probable that the mineral treasures of this extensive valley may in some measure compensate for its many other disadvantages. Of the quantity of iron ore and mineral coal laid open to the day along the banks of Missouri, Mr. Bradbury expresses himself in raptures. So small a part has been examined, and that so hastily, even by Mr. Bradbury himself, that no conclusive deductions can be made on any branch of the natural history of the valley of Missouri, at present.

Valley of the Mississippi, below the mouth of the Missouri.—We now approach what may be strictly designated as the tropical regions of the United States, though the entire surface of the section under review is not included under that government. The common recipient, the Mississippi, has been noticed under the head of that river in general; we may therefore observe, that the section under review extends in its greatest length from the mouth of the Mississippi to the sources of the Arkansaw, 1400 miles: the greatest width of the valley is, from the junction of the Mississippi and Missouri to the mouth of the Atchafalaya, 600 miles. The area of no section of the Mississippi basin can be determined with more difficulty than that under review. The sources and length of the two most considerable confluents remain uncertain to a very serious extent. In this article we have assumed 330,000 square miles, equal to 211,200,000 acres.

In respect to climate, the lower valley of the Mississippi extends from N. Lat. 29°, that of the mouth of the Mississippi, to N. Lat. 42°, the sources of Arkansaw river, or through 13 degrees of latitude, with a difference of elevation from the level of the Gulf of Mexico to at least 5000 feet. These extremes, when due allowance is made for difference of elevation, amount to 28 degrees of latitude.

The principal confluents of this valley, which enter the main recipient from the right, are, commencing below the mouth of Missouri, Merrimack, St. Francis, White, Arkansaw, and Red river; those from the left are, commencing below the mouth of Ohio, Kaskampa, Redfoot, Obian, Chickisaw, Forked Deer, Yazoo, Big Black, Homochitto, and Buffalo rivers.

Features.—The lower valley of the Mississippi is the most diversified section of the United States. Every variety of landscape, every trait of natural physiognomy, and an exhaustless source of metallic and vegetable production, is here found. This expanse is limited on the east by a dense forest, and on the west by the lofty but naked spines of the Chippewan mountains.

After receding about 100 miles from the banks of the Mississippi to the west, and in many places a less distance, prairies commence, which, gradually encroaching on the forests, finally spread one wide waste of grass, as on the higher branches of the general basin. The open plains of Arkansaw and Red rivers, are merely a continuation of those of the valley of Missouri, and with similar features. Those immeasurable plains of grass seem destined to be, in all future, as they have been in all former ages, the empire of ruminant animals, such as the buffaloe, deer, wild goat, or antelope, and wild sheep. Following this apparent law of nature, if those prairies should ever become the residence of civilized inhabitants—those inhabitants must be herdsmen, and not cultivators of the earth. As far as settlements have been made on one side of this grassy desert by the Spanish Americans, and on the other by the people of the United States, in western Louisiana and elsewhere, effects have followed natural causes, and the traveller finds a rude habitation on the banks of a brook or river, with a small field or two, in which a little maize and sweet potatoes are cultivated; and from thence the eye ranges over a shoreless sea of grass, on which cattle and horses are seen grazing in all directions. This is not the fiction of a sportive imagination; it is a reality which the eye that directs the pen that records the fact hath seen innumerable times. And it is here noted as illustrative of how much man is influenced in his modes of existence, his manners, and political condition, by the soil, climate, and other natural phenomena around him; and to the operations of which, as he cannot control, must submit. And such is the flexibility of human nature, that what was necessity becomes by habit pleasure, and the mounted herdsmen of New Mexico, Texas, Louisiana, and Arkansaw, would not change condition with any other people on earth. Free as the plains on which they rove are wide, these horsemen know no luxury beyond their herds, sigh for no distinction but that of managing their steeds with most adroitness.

Such is the germ of a people, which, in the short lapse of two centuries, will inhabit a surface more than equal to two-thirds of all Europe. The mind cannot detach itself from this truly interesting subject without reflecting, that, to the physical similitude between the deserts of Arabia and the steppes of central Asia, with the interminable plains of interior North America, a strong moral resemblance does, and ever must continue to exist between the respective inhabitants of those distant regions.

To the many other features in common between the prairies of Red and Arkansaw rivers, and the steppes of central Asia, is the prevalence of muriate of soda, (common salt,) which, as has been observed, renders the water of those rivers brackish.

When we turn our eye to the entire surface of the valley under review, we find it divided into two very unequal portions. The grand recipient, the Mississippi, is seen rolling almost at one extremity; a narrow strip of land, with rivers of very small comparative magnitude, skirt its left bank. This confined border of about 500 miles in length, by a mean width of 50 miles, amounting to 25,000 square miles, is opposed by an extent of

305,000 square miles, watered by the great volumes of White, Arkansaw, and Red rivers. Consequently the valley is divided into two sections, the proportions of which exceed 16 to 1.

Next to the Mississippi itself, the Arkansaw river would appear the most prominent object on this almost interminable landscape. When the Missouri is assumed as the principal stream, the Arkansaw, in point of length, ranks as its second confluent, being longer than either the Plate, Mississippi proper, or Ohio, which follow in order. The sources of the Arkansaw remain unknown to any precision, but are generally supposed to extend to N. lat. 42°, and W. lon. from Washington city 34°; the position of its mouth has long been sufficiently well known; it enters the Mississippi at N. lat. 33° 56′, and W. lon. from Washington city 14° 10′. This stream, therefore, winds through upwards of 8 degrees of latitude and 20 degrees of longitude. Its length, by comparative course, is about 1400 miles, but, by its meanders, must exceed 2000 miles.

The geography of the Arkansaw has now become an object of the first importance, as its channel forms, from the 100th degree of longitude west of London, to its source, if those sources are south of N. Lat. 42°, part of the limit between the United States and the Spanish dominions in America.

From the discoveries recently made by Captain Long, the magnitude of the Arkansaw has been hitherto underrated. A large body of water hitherto made to enter Red river, is now found to flow into Arkansaw by the Canadian Fork. The Arkansaw is more impeded by falls and cataracts, than any river of the great inclined plane we have noticed. Issuing from an elevated and mountainous region, the bed of this stream is unnavigable with large boats, except about 600 miles above its mouth. From thence it flows in a deep rapid channel, of about six hundred yards wide, to its junction with the Mississippi. The particular tributary streams of the Arkansaw remain in great part imperfctly known. This river now gives name to a territory of the United States, and in the lapse of a few years, will no doubt designate a state of the confederacy, similar to the Illinois, Missouri, ahd Mississippi.

Next in magnitude of volume, and length of course to Arkansaw, is Red river. Like its rival, Red river flows from that spine of mountains, which, ranging from Mexico northward, assumes local appellations in different places; in Mexico this chain retains the native Aztec name of Anahuac; near the sources of Red and Arkansaw rivers, it is known as the Mountains of New Mexico; and farther north as the Rocky Mountains, or the Chippewan.

Great uncertainty reigns over the sources of Red river; but, if the information given by Captain Long be correct, and it is entitled to great credit, those waters which originate from N. Lat. 32° to 35°, and W. Long. from Washington City from 25° to 28°, which in all our maps are represented as flowing into the Gulf of Mexico, by the Colorado and other streams, on the contrary, are the sources of Red river. By comparative courses, this stream is about 1000 miles in length; but following it by its meanders, is probably 1500 miles.

Both the Arkansaw and Red river have their regular periodical inundations, similar to the Mississippi, and enter their recipient at the season of flood respectively, with an immense body of water, which in no small degree contributes to supply that enormous mass of fluid which annually rolls over Louisiana into the gulf of Mexico. Arising from the saline and ochreous earths through which they flow, the waters of these two great rivers are in a considerable degree brackish; that of Red river so much so, that at Natchitoches, and from thence to its entrance into the Mississippi, cannot be used for either drinking or for culinary purposes.

Red river enters the Mississippi at N. Lat. 31° 01′, and W. Long. from Washington City 14° 40′.

The next confluent of the Mississippi, in point of magnitude, which enters from the right bank below the mouth of Ohio, is White river. This latter river, though of greatly inferior length or volume to the two former, is of great importance from the extent of excellent land it drains. White river rises in the angle between Arkansaw and Osage rivers, and has its sources mingled with those of both the latter, also with those of Merrimac and St. Francis. White river, after a comparative course of about 400 miles, falls into the Mississippi, a few miles above the mouth of the Arkansaw.

St. Francis and Merrimack would neither deserve particular notice amid the description of rivers such as we have been surveying, except as flowing from one of the most interesting metallic regions of this globe.

St. Francis rises in the counties of Washington and St. Genevieve, in the state of Missouri, and flowing south by comparative course 250 miles, enters the Mississippi about one hundred miles by water above the White river.

The Merrimack rises in the highlands between the sources of St. Francis and those of the Gasconade, a branch of Missouri, flows east by comparative course one hundred miles, enters the Mississippi eighteen miles below St. Louis.

It is unnecessary in this to notice the soil, climate, or productions of the lower Mississippi valley, as these subjects will come more appropriately under the respective heads of the states of Mississippi and Missouri, which see. A reference is also made to the article Mississippi state, as respects the confluents of the Mississippi river, from its left bank, below the mouth of Ohio.

Summary.

	Square Miles.
Valley of Ohio,	200,000
Do. Mississippi proper,	180.000
Do. Missouri,	500,000
Do. Lower Mississippi,	330 000
Total area of the Mississippi Basin,	1,210,000

We may here remark, that including the basin of Columbia, the Trans-Mississippian Territory of the United States amounts to 1,144,843 square miles, equal to 732,699,520 United States' acres.

To close the survey of the Mississippi Basin, it only remains to examine the general laws by which the annual floods of the Mississippi are regulated and determined. In order to elucidate this subject, it is necessary to combine under one view the entire surface of the basin. This investigation embraces one of the most important questions in physical geography; it is to examine one of the most stupendous operations of nature, performed on a scale commensurate with the magnitude of the effect.

In our review of the valley of Ohio, 320.8 feet was given as the elevation of the waters at the junction of Ohio and Mississippi rivers. From want of correct data as to the real length or general fall of its waters, no satisfactory calculation can be made as to the absolute elevation of the sources of Missouri. We have assumed in this article 3000 feet as the probable height, above the respective oceans, of the sources of the Missouri. In an analysis similar to that on which we are engaged, relative elevation is one of the elements most necessary to a correct result. We may remark in this place, with sincere regret, that during all the time in which our citizens have visited the sources of Missouri, that the elevation of not one peak or pass has been determined and published. We have, however, some facts which enable us, by analogy, to approach an accurate estimate of the height of the sources of the Missouri. From the extreme cold, and from the late continuance of snow at N. Lat. 45° or 46°, we cannot suppose the base of the Chippewan mountains to be in that region less than 2800 or 3000 feet. At the first glance, when it is known the great length of the stream, from its discharge into the gulf of Mexico to its remotest sources, so moderate an elevation of the latter may appear too limited; but 3000 feet would demand very nearly a foot per mile, an enormous descent, much more than double that ordinarily found in rivers. In the foregoing estimate, the absolute height of peaks, or even ridges, are not taken into account.

It has often excited astonishment in those who knew the extent, without duly attending to the structure of the Mississippi basin, that the entire Delta is not annually submerged. We now proceed to investigate the causes of the long continuance, and in common years, the moderate elevation of the Mississippi floods. Recurrence to a good map will render intelligible what is to follow, and render obvious, that the peculiar structure and relative position of the respective valleys which compose this great basin, are the true causes which prolong the duration, and mitigate the height of the annual inundation.

In conducting this review, we may consider the basin subdivided into the four valleys already noticed; that of Ohio, Mississippi Proper, Missouri, and Lower Mississippi. The relative extent of each has been determined, and the principal streams noticed. If we were to turn an attentive eye to a map of those four sections, and unaided by a single fact drawn from actual observation, it would follow from theory, from its more southern position, and from its length extending east and west, that the valley of the Lower Mississippi must first discharge its waters; the Ohio valley would follow; Upper Mississippi would succeed to Ohio; and lastly, would issue the discharge of Missouri, or largest subdivision of the basin: such are indeed the facts.

It would also be evident from inspection, that of every valley taken separately, nature opposes insurmountable obstacles to a simultaneous discharge. Red and Arkansaw rivers flow nearly parallel through fourteen degrees of longitude, and yet in every year the discharge of the former precedes that of the latter nearly a month. Red river is the true North American Nile, though on a smaller scale. That title has been bestowed on the Mississippi with unparalleled absurdity. Except in the single circumstance of each protruding a Delta at their respective mouths, no two rivers could possibly present more contrasted features than does the Mississippi and Nile. In fact, except in one circumstance, very little resemblance exists between the Nile and Red river: the Nile in common years has only one flood, Red river has often two; but the floods of the Nile are discharged by regular rise and as regular depression, which is eminently the case with Red river; a circumstance which, in a very striking manner, distinguishes both from the Mississippi, which rises and falls by pulsation, if such a term is admissible.

Near the north-west angle of Louisiana, a chain of lakes commences on both shores of Red river, which continue to skirt that stream upwards 100 miles. The writer of this article examined these lakes, and found them to be evidently formed in the ancient channels and adjacent low grounds of considerable water-courses, the discharge of which, into Red river, has been gradually impeded by a natural embankment, formed by the sediment brought down by that river. These lakes, as they now exist, are from four or five, to thirty miles in length, and from one quarter to three miles wide, and are filled and emptied alternately, as the floods of Red river rise and fall: they are in fact real reservoirs, which in the rise of Red river receive great part of its surplus water, and as the river depresses discharge that surplus slowly, tending very greatly to mitigate the rapid emission of the Red river flood on the Delta. As far as the writer is informed, this feature is peculiar to Red river, and distinguishes that stream from every other.

Red river, like the Mississippi, has a flood in autumn, but what may be denominated the annual inundation of that river reaches the Delta in February, and continues through March and April.

The efflux of Arkansaw uniformly succeeds that of Red river; but from the greater length of course, extent it drains, and also from the more northerly and mountainous country from which its remote sources are drawn, the volume of the former very greatly exceeds that of the latter; though from different causes, both rivers are alike in yielding their waters by a slow and regular discharge. The great mass of the flood of Arkansaw reaches the Delta in March and April, and is therefore simultaneous with the latter part of that of Red river. White river, in strictness, forms part of the Arkansaw tide, and flows out with the first flux of the latter stream.

We may here observe, that all the rivers of the Mississippi basin, above N. Lat. 37°, are liable to be annually frozen. The Mississippi, at St. Louis, is three years in five passable on the ice with loaded carriages, by the first week in January. The Ohio, in an equal latitude, is not so soon frozen, though the cold is equally intense on the latter, as on the former river. The causes are obvious which produce this apparent anomaly. The waters of the Mississippi, flowing from high latitudes, are cooled almost to the point of congelation, when they arrive at the junction of the Mississsippi and Missouri; whilst those of Ohio, in the latitude of St. Louis, flowing nearly from east to west, demand a longer exposure to frost to become frozen. The gradual melting of the ice and snow above the latitude assumed, that of 37°, is another very controlling cause of the slow emission of the general flood.

The Ohio valley, from its compact form, greater comparative descent, and from the medium climate in which it is situated, emits its waters with more irregularity than any stream in the Mississippi basin. The Ohio tide of flood occurs from November until March, inclusive, though perhaps four years in five, this river yields the principal discharge in the latter month. The floods of this valley are more sudden in their rise, and more impetuous in their discharge, than that of any other section of the Mississippi basin. The main tide of

Ohio reaches the Delta in May. The various streams are, however, so relatively placed, as to render a simultaneous discharge impossible. The effect, therefore, of this river, in producing an augmentation of the floods which inundate the Delta, is much lessened in its operation.

The Mississippi proper is still more disadvantageously situated, to admit a rapid emission of its waters than the Ohio. Flowing nearly in a north and south direction, and through so great a range as nine degrees of latitude, the more southern confluents must be very much exhausted before those towards the source are relieved from fetters of ice. The great body of the Mississippi tide is, however, coeval with that of Ohio.

It is the accumulation of the waters of the three valleys we have surveyed, and those of the Kanses and Osage branches of the Missouri, which produce what is known as the annual Mississippi inundation. This flood, nine years in ten, reaches the highest point of its elevation at Natchez, between the 10th and 20th of June. Few instances occur, in a long succession of years, in which the waters at that city have not commenced their depression by the first week of July. And yet, the heaviest mass afforded by the largest natural section, has not yet reached the Delta.

Powerful as are the natural causes which combine to prolong the discharge of the enormous body of waters contained in the three sections of the Mississippi basin we have examined, none contain such controlling impediments to an aggregated and sudden emission, as does the Missouri valley above the Platte inclusive.

The Yellow Stone and Missouri spread their sources through seven degrees of latitude, and, assuming a general course of south-east, unite their waters above N. Lat. 48°, turn to the east and south-east, and finally assume, at the Mandan Villages, a southern course, after having flown through eleven degrees of longitude. The Platte pursues a general course from west to east, above N. Lat. 40°, and flows through fourteen degrees of longitude. It must be obvious, from what has been shewn in this article, or by inspection of a good map, that the higher branches of Missouri must remain frozen, long after those more southward have commenced their rise, and nearly as late as the period of high tide on the Delta. The mean motion of the entire mass of water, in any of the confluents of the Mississippi, does not much, if any, exceed one mile per hour; therefore, between three and four months are necessary for the passage of water from the extreme sources of the Missouri to the Delta of the Mississippi; consequently, though those waters commence their rise in May, they do not frequently reach the Delta until late in July, or early in August, consequently at a period when the main spring and summer inundation is very greatly abated, and the water retired within the banks of the Mississippi river.

Though the period of flood is well known to the inhabitants of the Delta, and in common years can be calculated within a few days, such is the inequality of the seasons over the whole basin, that no length of experience gives much aid in estimating the probable elevation or quantity. In 1800 and 1801, the waters of the Missisippi at Natchez did not attain the height of the banks.

The Delta commences at the mouth of Red river, or, more correctly, at the efflux of the Atchafalaya. At this place is a gorge, through which the overwhelming mass of surplus water is confined to within three miles; but by the channel of Atchafalaya, a very large quantity flows out to the right from the main stream, never again to return. One hundred and twenty miles lower, flows from the left, the Manchac or Iberville. Those two streams, the Atchafalaya and Iberville, bound the Delta, and below their efflux respectively, no water which flows from the Mississippi ever returns; nor are there any bodies of arable land, except upon the immediate banks of the water-courses; all beyond, is either swamp or morass.

MISSISSIPPI, one of the United States of North America.

Situation and Extent.—Having the Mississippi and Pearl rivers on the west; the 35th degree of N. Lat. or the state of Tennessee, north; the state of Alabama on the east; and the Gulf of Mexico, and N. Lat. 31°, or Louisiana, on the south. The outlines of this state are:

	Miles.
From the mouth of Pearl river along the Gulf of Mexico, to the south-west angle of Alabama, .	80
Along the western boundary of Alabama, to the north-west angle of that state, on the southern boundary of Tennessee, ...	320
Thence west along the southern boundary of Tennessee, to the south-west angle of that state on the left bank of the Mississippi river, . .	90
Thence down that stream to N. Lat. 31°, . .	530
Thence due east along N. Lat. 31°, and the state of Louisiana, to the right bank of Pearl river, .	105
Thence down Pearl river, to the place of beginning,	60
Having an entire outline of	1185

Area 45,760 square miles, equal to 29,286,400 acres. Extreme south, N. Lat. 30° 8′; extreme north, N. Lat. 35°. Length from south to north, 338 miles; medium width, about 135 miles.

The remarkable resemblance in form and geographical position, between the states of Alabama and Mississippi, is obvious on a first glance on their connected maps. In addition to every other point of similitude, both have a prolongation towards the Gulf of Mexico, below N. Lat. 31°, of nearly equal area and extent on that Gulf.

Features, Soil, Climate, and Productions.—Of the rivers of the state of Mississippi, that stream from which the name of the state is derived, claims the first rank.

The Mississippi washes the state from N. Lat. 31° to 35°, a distance, following the stream, of 530 miles. The features of the Mississippi have been so amply noticed under the preceding head, that no farther notice respecting it is necessary in this place.

Next in magnitude and importance amongst the rivers of this state, is the Pearl. This stream rises in the state, about N. Lat. 33°, and flowing in a general course nearly south, flows into the Rigolets between Lakes Borgne and Pontchartrain, at N. Lat. 30° 10′, after an entire comparative course of about 200 miles. From N. Lat. 31° to the mouth of the Pearl, forms part of the boundary between the states of Louisiana and Mississippi.

The Pascagoula rises in the state of Mississippi, about N. Lat. 32° 40′, flows in a southern course to N. Lat. 30° 20′, falls into the Gulf of Mexico after a comparative course of about 150 miles. The main branch of Pascagoula is known by the name of Chickisawhay, as far down as five miles south of N. Lat. 31°, where it forms a junction with the north-west branch, the Leaf river, and from thence to the final discharge takes the name of Pascagoula.

Some streams, but of small note, enter the bay of St. Louis between the Pearl and Pascagoula rivers.

The sources of the Amite, Tickfoha, Tangipao, and Bogue Chito rivers, are in the state of Mississippi.

Flowing into the Mississippi, are the Buffaloe, Homochitto, Big Black, and Yazoo rivers. Of these latter streams, in point of magnitude, the first rank is due to the latter. This river has its source near the southern boundary of Tennessee, interlocking with the head waters of Tombigbee. The Yazoo enters the Mississippi at N. Lat. 32° 30′, after a comparative course of about 200 miles.

Big Black rises about N. Lat. 33°, between the sources of the Pearl and the Yazoo, flows south-west 150 miles, and falls into the Mississippi at the Grand Gulf, N Lat. 32° 5′.

Between the Big Black and Homochitto, the Mississippi river receives the water of Bayou Pierre, Coles creek, and St. Catherine creek; these creeks are comparatively small, but important from their position, and the excellence of the land they drain. The city of Natchez, though so near the bank of the Mississippi, is situated on a branch of St. Catherine creek, which has its discharge 15 miles below.

The Homochitto river rises about 50 miles north-east from Natchez; flows south-west about 100 miles; enters the Mississippi at N. Lat. 31° 12′.

The Buffaloe is rather a creek than a river, not having a course of more than 25 or 30 miles. This stream rises in Amite, and flows west through Wilkinson county, and falls into the Mississippi two miles above Loftus Heights.

The Tennessee river forms a part of the boundary of the state of Mississippi, from the mouth of Bear creek to the Tennessee line, at N. Lat. 35°, about 20 miles, and ought consequently to be classed as one of the rivers of the state.

We have already observed, that the sources of the Tombigbee were in the state of Mississippi. The sources of Tombigbee rise near the Tennessee line, flow to the south-east, and enter the state of Alabama at about N. Lat. 33° 30′.

The state of Mississippi has a very confined and incommodious sea-coast, of 80 miles in extent. In this distance, the Pascagoula is the only inlet by which vessels of the smallest size can enter, and in that only schooners of small draught, at high water, can reach the junction of Chickisawhay and Leaf rivers. The Pearl admits no navigation worth mention; and the bay of St. Louis is a mere indentation of the coast, of no practical use in a commercial point of view.

The Mississippi river is the great harbour and outlet of the state.

The state of Mississippi is naturally divided into four grand divisions of soil. The islands in Lake Borgne, and the Gulf of Mexico; Pine Forest; Mississippi, and other river alluvion; and the Mississippi Bluffs.

Advancing from south to north, first occurs a chain of low sandy islands, lying about six or seven miles from the main shore; their names are, ranging from west to east, the group of the Malheureux (unfortunate) Islands; Mary Anne, Cat, Ship, Dog, Horn, and Petite Bois Islands.

The opposing shore, once a part of West Florida, is a level pine forest to the water edge; constituting the second, and by far most extensive superficies of soil in the state. Receding from the shores of the Gulf inland, the face of the country imperceptibly swells into hills, and though no part of the state rises into elevations that can be designated mountains, much of its surface is extremely broken.

Next in extent to the Pine Forest land, is the range called the Mississippi Bluffs; and lastly, the more confined, but greatly most valuable land, where found above annual overflow river alluvion. Of these three latter divisions of soil in order.

As we have already observed, the Pine Forests reach the waters of the Gulf of Mexico; and, we may add, extend in the intervals between the streams, to the northern extremity of the state. This species of soil, deriving its title from the principal timber it produces, in most places gradually mingles with the river alluvion, or Mississippi Bluffs, and produces an intermediate soil partaking of the qualities of both; and on which oak, ash, hickory, dogwood, sweet gum, and other trees, intermingle with the pine. This mixed soil and timber is known in the country by the name of interval land, and is often found very productive. The pine lands have hitherto been considered extremely sterile; how far future modes of culture, or artificial means, may tend to meliorate this species of soil, remains an undecided problem.

In the northern parts of the state of Mississippi, towards Tennessee, the pine woods are frequently interrupted by a species of prairie, or rather barrens, on which grow shrub oak, and other dwarf bushes; but the soil continues to exhibit the unproductive character of that of the pine woods.

It would not be hazarding much, to estimate the extent of these barren tracts at two-thirds of the entire area of the state.

In all the length of the state of Mississippi, from N. Lat. 31° to 35°, a range of bluffs extend. These bluffs reach, and are washed by the Mississippi in a few places only. Immediately above N. Lat. 31°, rises the highest of these bluffs, known by the name of Loftus Heights, which skirt the river four or five miles. A very large curve of the Mississippi, to the west, leaves an extensive overflown tract along the right bank, as high as Ellis's Cliffs, where, by an eastern curve of the river, the bluffs are again washed by the stream; which is also the case at the city of Natchez. Above the latter place, the bluffs and river do not again come in contact below the Grand Gulf at the mouth of the Big Black river. The bluffs again reach the stream at Walnut Hills, below the mouth of the Yazoo, and at the Chickisaw Bluffs, immediately at the north-west angle of the state.

These bluffs are the mere extension of the comparatively elevated surface of the state of Mississippi over the low grounds of the river of the same name. When the waters are low, it is found that the bluffs are underlaid by a crude concrete of sand and pebbles, held in mass by an oxide of iron; the whole, no doubt, resting on a secondary base.

The elevation of the bluffs vary, but about one hundred feet medium height would not be a serious departure from fact. They are cut into hills by the abrasion of water of the numerous streams which flow from the pine woods in the interior.

What renders these bluffs and hills objects of peculiar intererst, is the quality of the soil, which is in almost all places good, and in many exuberantly fertile. Receding from the bluffs, the pine forests imperceptibly encroach, and in some places, at a more or less distance from the river, say in a direct line from fifteen to twenty miles, closes the productive border.

The foregoing limit is taken in general; many of the water-courses have fertile tracts on their banks, farther into the interior of the state; but the latter description of land belongs more particularly to river alluvion, than to the soil of the bluffs or hills.

The soil of the bluffs and hills is a rich loam, resting on clay; and digging wells has disclosed the fact, that the general substratum to the clay is loose sand.

The whole of this fine border of soil, in a state of nature, is covered with a very dense forest, with an underwood of reed cane, the Arundogigantea, many species of vitis, smilax, and other climbers, and an infinite variety of more humble vegetables.

A mere list of the most prevalent timber trees will serve to demonstrate the fertility of this tract: these are,

Black-oak, Quercus tinctoria.
White-oak, Quercus alba.
Spanish-oak, Quercus falcata.
Black jack-oak, Quercus ferugínea.
Willow-oak, Quercus obtusiloba.
Wild-cherry, Cerasus Virginiana.
Sweet gum, Liquidambar styraciflua.
Poplar, Liriodendron tulipifera.
Large laurel, Magnolia grandiflora.
Beech, Fagus sylvestris.
Fagus pumila, here a tree often forty feet in height, and eight or ten inches diameter.
Black locust, Robinia pseud acacia.
Mulberry, Morus rubra.
Persimon, Diospiros Virginiana.
Honey locust, Gleditsia tricanthos.
Black gum, Nyssa sylvatica.
Cottonwood, Populus angulata.
Linden, Tilia pubescens.
Muscilaginous elm, Ulmus Americana.
Red elm, Ulmus rubra.
Sassafras, Laurus sassafras.
Sycamore, Platanus occidentalis.
Ash, Fraxinus tomentosa.
Black walnut, Juglans nigra.
Bitternut hickory, Juglans amora.
Nutmeg hickory, Juglans myristiecæformis.
Red flowering maple, Acer rubrum.

Of more humble trees and shrubs, and other vegetables, the following are most indicative of fertility of soil.

Papaw, Annonatriloba.
Dogwood, Cornus florida.
Spicewood, Laurus benzoin.
Spanish mulbery, Morus scabra.
Buckeye, Pavia.
Poke, Phytolacca decandra.
Blackberry, Rubus villosus.
Muscadine, Vitis verrucosa.
Reed cane, Arundogigantea.

It would swell this article to too great length, to give a mere list of the most interesting vegetable productions of the fine tract under review; the foregoing are inserted as illustrative of its natural fertility.

When compared with the entire area of the state, the productive tract before us is confined in extent; but when we turn our attention to the exotic vegetables which are, or can be produced within its limits, the intrinsic value of the land is rendered apparent.

Indigo, tobacco, and cotton, have in turn been cultivated as staples, and produced in great abundance: the latter has for more than twenty-five years past superseded the two former, and will, in all human probability, continue the great staple of this part of the United States.

Much speculation has been made upon the quantity of cotton which is, or can be produced per acre, upon the bluff lands. The writer of this article, from some personal experience, will undertake to assume 250 pounds of clean cotton as about an average crop.

To cotton, indigo, and tobacco, may be added, as the exotic plants cultivated in the state of Mississippi, Indian corn, (zea maize,) oats; and, where the inhabitants choose, wheat may be produced; but the culture of that grain is seldom attempted. Most garden plants grow luxuriantly, though good gardens are rare. That species of potatoe, the tuberous rooted solanum, commonly called Irish potatoe, is cultivated, but does not succeed so well, either as to quantity or quality, as the same vegetable does farther northward. The sweet potatoe (convolvulus batatas of Muhlenberg) is produced in the utmost abundance.

Of cultivated fruits, the principal are the apple, peach, and fig, the latter, below N. Lat. 32°, seems to flourish as if natural to the climate. The plum, nectarine, apricot, &c. are cultivated, but not extensively.

Like all the southern states of the United States, meadows cannot be correctly said to exist in the state of Mississippi.

Though the winters are in general mild, the seasons are extremely variable. Frequently frosts occur in sufficient severity to destroy cotton, indigo, tobacco, and other tender plants, as early as the first week in October; whilst perhaps, in the next season, the flowers of the same vegetables will be found blooming in December, and even in January, as was the case in 1805.

No winter, however, passes without frost, and very few without snow, at Natchez. In December, 1800, the thermometer of Fahrenheit fell to 12°, five miles south of Natchez; and often since that period, the cold has been nearly if not altogether as intense. This casual severity prevents, to the utmost southern extremity of the state, the cultivation of either sugar cane or the orange tree; vegetables which are, in fact, confined in the Delta of the Mississippi to a latitude south of most parts of the state of Mississippi.

The bluff lands are followed by the river alluvion, which, though less in quantity, is still more productive, where above annual or casual overflow. From the bluffs confining, and of consequence causing the accumulation of the surplus water of the Mississippi in the spring and summer, there exists less arable soil on the left bank of the Mississippi river, in the state of that name, than on the right bank in Arkansaw territory, and in Louisiana. Some very wealthy settlements on the left bank do, however, exist, with a soil possessing the usual fertility of the Mississippi banks. The arable border varies from half a mile to two hundred yards, and is every where terminated in the rear by overflown grounds, submerged annually from one to ten or twelve feet.

The natural growth on the river arable border is, in general, sweet gum, different species of oak, ash, and hickory, hackberry, sycamore, &c. with an under-growth of reed cane, and below N. Lat. 31° 30′, the palmetto. In the overflown swamps, the principal timber is cypress, tupelo, different species of oak and hickory, maple, sweet gum, and ash. On all other water-courses in the state, more or less alluvion occurs; but in all places is confined in extent, and on the streams in the interior, often merges into the interval land or pine forest.

Taken together, the bluff lands and river alluvion amount to about 5560 square miles, equal to 3,558,400 acres. The bluff lands extend from N. Lat. 31° to 35°, with more or less width, as the rivers intervene.

Confined as the two foregoing tracts of land are, when compared to the area of the state, of which they form a part, they nevertheless form, in the aggregate, the most extensive continuous tract of productive soil in the United States, south of N. Lat. 35°; and when its fertility and local advantages are taken into view, it is hazarding no violence to truth, to estimate this region as one of the most valuable in the United States.

Counties, Towns, Population, and Historical Epocha.— In the state of Mississippi there are 15 counties, as follows, commencing at the south-east angle of the state.

Counties.	Chief Towns.
Jackson,	
Hancock,	
Green,	
Wayne,	
Covington,	
Marion,	Jacksonville.
Pike,	Holmesville.
Lawrence,	Monticello.
Amite,	Liberty.
Franklin,	Franklin.
Wilkinson,	Woodville.
Adams,	NATCHEZ.
Jefferson,	Huntston, or Greenville.
Claiborne,	Gibsonsport.
Warren,	Warrenton.

The returns of the census of 1820 have not yet been received from this state, but the number of inhabitants probably amounts to within a trifling fraction of 60,000; one half of whom are black, or of mixed breed. Of this population, more than half are contained in the five counties bordering on the Mississippi river, Wilkinson, Adams, Jefferson, Claiborne, and Warren. Franklin and Amite, lying east of Adams and Wilkinson, are, after the river counties, best peopled. Lawrence, Pike, and Marion, situated on the waters of Pearl and Bogue Chito, and immediately east of Franklin and Amite, are but thinly peopled; and the five south-eastern counties, Covington, Wayne, Greene, Hancock, and Jackson, have still fewer inhabitants on an equal surface, than are found in Lawrence, Pike, and Marion.

The country near Natchez was settled by the French in 1718, and Fort Rosalie built on the bluff, within the now incorporated limits of that city. The first French colony was massacred by the savages in 1729, and the country remained uninhabited by the whites many years afterwards.

In 1763. Natchez, then considered a part of West Florida, was ceded by Spain to Great Britain, who retained possession until 1781, when that place and all West Florida was conquered by the Spaniards under Governor Bernardo Galvez; and, by the treaty of Paris, West Florida was confirmed to Spain. As the limits of the British and French colonies, and afterwards those between the British and Spanish colonies, had never been fixed, the Spanish authorities held Natchez and the adjacent country as an appendage of Florida until 1798, when the city and country were evacuated by the officers and troops of Spain, and the United States commissioners took full possession. In 1799, the line of demarcation was completed, and the boundary fixed, which now separates the states of Louisiana and Mississippi, between the Mississippi and Pearl rivers.

April 7th, 1798, an act of Congress was passed, authorizing the President of the United States to appoint commissioners to adjust the limits of the territory west of the Chatahoochy river.

May 10th, an act was passed for the organization of a government, and the territory named "The Mississippi Territory."

June 9th, 1808, an act passed, admitting a delegate from the Mississippi Territory in Congress.

June 17th, 1812, the assent of Georgia demanded, for the formation of two states out of the Mississippi Territory. This demand was subsequently acceded to by Georgia.

January 21st, 1815, a petition from the legislature of the Mississippi Territory laid before Congress, praying admission into the Union on the same footing with the original states. A committee of Congrees reported on this petition favourably, December, 1816.

A law was passed in consequence, March 1st, 1817, authorizing the call of a Convention, which was called, and met July, 1817, accepted the terms proposed by Congress, framed a constitution, August 15th, which was accepted by Congress in December following; and the state of Mississippi assumed her station as a member of the United States. Since the period of admission, no event of consequence, in a general view, has taken place in this state.

MISSOURI RIVER. See MISSISSIPPI *Basin*, p. 623.

MISSOURI, one of the United States of North America.

Situation and Extent.—The state of Missouri is bounded, north-east and south-east, by the Mississippi river; south by the territory of Arkansaw; and west and north by the western unappropriated territory of the United States, formerly a part of Louisiana.

The limits of Missouri are:

	Miles.
Beginning on the left bank of the Mississippi river at the mouth of Lemoine river, and thence down the former stream to where it is intersected by N. Lat. 36°, ...	550
Thence due west, along N. Lat. 36°, to the right bank of St. Francis river, ...	50
Thence up St. Francis to a point where that river is intersected by N. Lat. 36° 30′, ...	50
Thence due west, along the territory of Arkansaw, to a point where a meridian line, drawn from the junction of the Missouri and Kanses rivers, will intersect N. Lat. 36° 30′, ...	200
Thence due north to a point, where a line extended due west from the Sac Village, on Lemoine river, will intersect the west boundary, . .	273
Thence due east to the Lemoine river, . .	130
Thence down the Lemoine river to the place of beginning, ...	20
	1273

Area within a trifling fraction of 63,000 square miles, equal to 40,320,000 acres. Mean length from north to south, 280 miles; mean breadth from east to west, 220 miles. Extreme south N. Lat. 36°. Extreme north N. Lat. 40° 26′.

Missouri, in point of extent, is the third state of the United States, and only falls below Virginia and Georgia.

Features.—Though part of this state is hilly, and some of the hills approach in elevation the dignity of mountains, yet, strictly speaking, no mountains, either in detached groups or chains, exist within the limits of the state.

For every object of human affairs, rivers are the most important features of an inland country, and few regions of the earth, of equal extent, can compare with Missouri in the magnitude, number, and navigable facilities of its rivers.

Of these, the first in order is the Mississippi and Missouri, both of which have been already so amply noticed in our description of the Mississippi Basin, that no further account of them is necessary in this place.

The Lemoine river, though for a few miles forming part of the boundary, can scarcely be called a river of Missouri. The Osage, rising in the territory of Arkansaw, and flowing north-east into the Missouri, is the most important confluent of that river in the state of Missouri. The Osage has its mouth near the centre of the state, where the future seat of government is intended to be placed. The Osage is a large navigable stream in all its length in the state, and waters some excellent, and much good land.

Besides the foregoing large stream, the Missouri receives from the right, below the mouth of the Kanses, Blue Water, Gasconade, and some smaller streams; and from the left, Grande, Charlaton, Good-Woman's, Great Manitou, Otter, and Charette rivers. The Merrimack enters the Mississippi 18 miles below St. Louis, but has been noticed under the article Mississippi Basin, as have been White and St. Francis rivers, which closes the list of the streams of the state of Missouri.

The position of Missouri is in a high degree favourable to commerce, population, and wealth. Extending four and a half degrees of latitude, its temperature must vary considerably, if uninfluenced by any other cause than mere geographic extent. This is not, however, the case, as will soon appear.

In conducting this general survey, I have endeavoured, in a particular manner, to delineate those features which influence the meteorological phenomena, and the temperature of the seasons, and also to point out the great outlines of soil. In respect to Missouri, it will be necessary to deviate from the strict observance of the plan pursued in describing the state of Mississippi. Instead, therefore, of dividing the former state into its natural sections, in relation to soil, we will take each of its river districts by itself.

We have seen that the river Mississippi washes Missouri on its north-east and south-east frontier, 550 miles, following the meanders, though, by comparative course, the distance along the Mississippi would not exceed 350 miles. Though the mere banks of the Mississippi preserve a nearly uniform character in all their extent along the front of Missouri, yet, from difference of climate, the vegetable productions are very different at the two extremes. So much has already been said on the features and quality of the alluvial margins of the Mississippi, that it is needless to amplify on the subject.

Ascending the Mississippi from its mouth, no eminence is to be found on its western bank in a distance of upwards of 1000 miles. Twenty-eight miles above the junction of Mississippi and Ohio, occurs the first rocky bluff on the right bank. It is composed of an enormous projecting precipice of limestone, whose real height above the water has never been very satisfactorily determined. This ledge is, no doubt, a continuation of the great limestone formation of the Ohio valley. In Missouri, it is a part of a ridge of hills which continues from this point westward, through the state, and ranges between the waters of Arkansaw and those of Osage and Kanses rivers, perhaps to the Chippewan mountains. This ridge divides Missouri into two very distinct climates. In the south-eastern part of the state, along the Mississippi river, the cotton plant is cultivated, though only for family use; as an object of commerce, it offers no great advantage: but, above the ridge in question, that plant ceases, and a region commences favourable to the production of the cereal gramina.

Near the Mississippi, below the limestone ridge, the banks are in every respect similar to what they have been described in Louisiana. The rear lands, as far as the St. Francis, are analogous to grounds similarly placed, in all the distance from the limestone range to the sea marsh.

The St. Francis rises partly in the hills of the limestone ridge, and in part from the drain of the Mississippi. The north-eastern branch of that stream appears to have been formed from an ancient outlet of the Mississippi, and to have contained a volume of water much larger than passes by its channel at present. The ordinary distance between the two rivers is about 50 miles, flowing nearly parallel from N. Lat. 37° to N. Lat. 34° 30′, where the St. Francis, by a gradual curve towards the lower part of its course, joins the Mississippi. The north-western branch rises near N. Lat. 38°, in a very hilly, broken, rocky, and barren tract of country. There are some good lands, but in no quantity commensurate with the extent drained by this river, whose whole length, by comparative course, is 250 miles, one half in Missouri, and the other in Arkansaw. Extensive settlements have been made on the sources of the St. Francis and its tributaries. According to the very respectable testimony of Mr. Schoolcraft, from personal observation, the country from which the western, or rather north-western source of St. Francis flows, is primitive, composed of granite, gneiss, and other congenerate rocks; amongst which are situated one of the richest iron, and the most abundant lead mine on the globe. The geological notices of Mr. Schoolcraft deserve the utmost attention; because made by a professed mineralogist, and a man who visited the region to collect facts, and not to support any pre-conceived theory. This gentleman has been, it must be acknowledged, much too general on a fact so important as the existence of a primitive region west of the Mississippi, and so near that stream. He has, however, enriched our literature with by far the best account extant of the mineral resources of Missouri, and very correct, though brief notices of its soil and vegetable productions.

Black river, the north fork of White river, rises in the south-western part of Missouri, by a number of branches, of which Strawberry river, Spring river, and Currents river, are the principal. The sources of Black river are in the ridge of hills, or rather mountains, which has been already noticed. The base of the country drained by Black river is calcareous, consequently the soil is very productive. The climate, as to temperature, is in no respect essentially different from that of St. Francis. The former, from superior elevation and more exemption from stagnant water, is no doubt much more salubrious than the latter. Like all calcareous regions, that of Black river affords some very large fountains of water, from one of which Spring river takes its name. The surface watered by Black river is about 8000 square miles. The timber is extremely large and varied. On the streams, cotton wood, different species of hickory, oak, and elm, prevail. The sugar maple is found, but the climate is rather too far south for the profitable extraction of its sap. The Liriodendron tulipifera is also found in this section of country of an enormous growth. Oak is, however, the prevailing tree on the waters of Black river. Like Tennessee, and the southern parts of Kentucky, the vegetation of the southern section of Missouri partakes of the specific variety of the northern and southern extremity of the United States. Cotton is cultivated, but rather for domestic use than as a commercial staple. The cereal gramina produce abundantly: though, on the verge of the prairie country, Black river drains a very dense forest. In fine, that part of Missouri, south of the ridge we have alluded to, and watered by St. Francis, Black, and Mississippi rivers, may be with propriety considered as naturally connected with the Arkansaw basin, though politically included in Missouri. The ridge is generally clothed with pine, the soil sandy, and extremely sterile. It in fact divides the state into two unequal zones, of very different temperature.

The Merrimack rises near the centre of the state; has its source in the dividing ridge, though its course is nearly east along its northern slope. The length of the Merrimack is not above 120 miles, comparative course. Its sources are in a sterile pine forest, and most of its banks partake the character of the soil from which it flows. It is an unimportant stream in either a geographical or agricultural point of view, though, in respect to mineral wealth, one of the most remarkable in the United States.

The mine tract, according to Mr. Schoolcraft, the best authority on the subject, extends in length from the head waters of St. Francis, in a north-west direction, to the Merrimack, a distance of 70 miles, and from the Mississippi, in a south-west direction, to the Fourche à Courtois, a distance of about 45 miles, and covering an area of 3150 square miles. The same author remarks, that it is not in every section of it that lead is to be traced, and he describes the mineral character of the soil, rocks, and other fossil bodies of this tract, as subject to so much variety, as to render indications of ore difficult to reduce to any safe result. The aspect of the country is sterile, hilly, and in many places precipitous. Many highland barrens, level but sterile, chequer the mine district. The soil in general is a reddish coloured, hard, stiff clay, admixed with much siliceous gravel. Nodules of iron-ore and pyrites are frequent. The mineral hills are covered in most places by a stunted growth of oaks, principally the post oak, the quercus obtusiloba of Michaux. A line of pine separates the sources of St. Francis from those of Merrimack, and passes through the mine tract in a direction from north-west to south-east. Though in general the soil of this tract is unproductive, the banks of some of its streams are very favourable exceptions. This fact is elucidated by the forest trees found on this alluvial soil; which are, sycamore, elm, cotton-wood, walnut, maple, buckeye, hackberry, ash, papaw, spicewood, and other trees and shrubbery, indicative of fertile land. Mr. Schoolcraft mentions a fact, of which, from the accompanying remarks, he seems not to have understood the cause. He observes, that around many of the mines, the earth, thrown out and raised from great depths, produces trees and shrubs which are not peculiar to the surface, and instances the cotton-wood, or poplar, and beach-grapes, the vitis riparia, I presume. He states, that he frequently saw those vegetables growing near old diggings, where the earth had been raised thirty or forty feet, and where, previous to those diggings, no such trees or vines existed. It is well known to botanists, that the seeds of many, perhaps most plants, if buried at great depths in the earth, will retain their vegetable organization for countless ages. The indestructibility of the seeds of plants is, indeed, one of the most curious subjects of philosophical reflection and research. Mr. Schoolcraft ascribes the cause of the phenomenon to that opprobrium of science, equivocal generation: a supposition at variance with all the laws of analogy, as applied to organized beings. The fact proves unequivocally, that the country has underwent great changes in its external crust, since the vegetables cited deposited their seeds in the soil, now covered by extraneous and very different bodies.

Here, as in every other place where silica forms a large part of the soil, the spring water is clear, cool, and of course wholesome; and being exempt from the causes that produce disease, stagnant water and decaying vegetables, the mine country is possessed of an atmosphere of the utmost salubrity.

The change of climate between the region watered by Black and St. Francis rivers, and that by Merrimack, is apparent in the vegetables cultivated by the inhabitants of each. On the Merrimack, wheat succeeds extremely well, a fact no where perceptible south of the dividing ridge. Wheat, and indeed all the cerealia, may be, it is true, cultivated even in Louisiana; but below the 38th degree of north latitude, wheat, rye, and barley, evince that they are removed from their congenial climates; and in no part of North America, except some of the table land of the great spine of Analinac, or Chippewan, where elevation compensates advance towards or into the tropics, does the cereal gramina, except maize, attain the full development of their growth. And even maize, in Louisiana, Mississippi, and Alabama, does not by any means attain the rich and abundant produce of that grain, as in the Mississippi basin, above N. Lat. 35°. The same remark applies in a striking manner to the apple. This most valuable of all tree fruits deteriorates about the same latitude with wheat. The apple, west of the Mississippi, first grows to advantage above the mine district. The peach-tree finds its most congenial air about N. Lat. 38°, though it is a fruit possessing in the United States a much wider range than the apple.

The Osage rises about N. Lat. 37°, W. Long. from Washington City 21°, and flows east a little north, having a comparative course of four hundred miles, one-third of which is in Missouri. This river rises in the great western prairies, and, like every stream of that region, exhibits some very productive, and a large proportion of steril land. Its meanders are in the lower part of its course very winding, consequently it contains much alluvial soil in proportion to its length, estimated comparatively.

The banks of the Missouri and Mississippi are uniformly in a high degree productive, and contain perhaps one-third of all the valuable arable land of the state. The right shore of the Mississippi is, from Tewapaty bottom to the mouth of the Missouri, in most places, an enormous limestone wall. This distance is about 170 miles. This limestone is merely the buttress of the underlaying strata of the interior country. The Mississippi flows in a deep channel, whose sides are elevated near 200 feet above its highest surface. Those precipitous banks are continued in the Missouri. The rich alluvial bottoms are at the base of this limestone precipice, and no doubt derive much of their fertility from the calcareous *debris* that the abrasion of the waters, in past ages, have worn away and deposited below.

About one-third part of Missouri lies north of Missouri river, and west of Mississippi river. This, in point of soil, is much the best part of the state. It is more uniformly fertile, though less diversified in surface, than the section south of Missouri, and south-west of the Mississippi river. The northern section is also much chequered by small rivers, which generally flow south into Missouri, and though mostly forest land, some extensive and very productive prairies occur. South of Missouri, there exists no medium between the best and worst lands, and similar to all those parts of the United States below the Missouri, and west of the Mississippi, the good soil extends in lines mostly upon the alluvial banks of rivers, or along the margin of prairies, and, consequently, can never admit a dense and scattered population. This is not so much the case with the northern section; the farms will assume in that quarter something of the promiscuous extension over the face of the country, which is characteristic of settlements in the northern and eastern states.

Taken as a whole, Missouri, like most new countries in the United States, has been, as a body of arable land, greatly overrated. As a commercial position, if due allowance is made for its internal situation, the value of this section of our country has never yet been duly appreciated. The truly astonishing assemblage of rivers, which seem to have sought a common centre of union, would indicate St. Louis, or some other place in its vicinity, as the future *entrepot* between widely extended, and far distant portions of our empire. If the pursuits of mankind, and their individual means of subsistence, were exclusively agricultural, Missouri could never, in proportion to territorial extent, possess a population equally dense with New-York, Pennsylvania, Ohio, Indiana, or Illinois; but in the complex admixture of employment, and the illimitable transmission of the products of human labour, arising from the improvement of modern manners and arts, population does not depend for its entire subsistence upon the quality of the soil inhabited by any portion of mankind. Commerce and the plastic arts demand, perhaps, as many hands as agriculture. There is indeed no employment of human labour, where so great a surplus is produced as that of agriculture; and none, in which the industry of a few will so effectually supply the wants of many. It is for this reason that the density of population must, particularly in such places as Missouri, depend as much, if not more, upon commercial, mining, and manufacturing pursuits, as upon the operations or resources of agriculture. In addition to the apparently inexhaustible stores of lead ore, some of the most abundant iron mines in the world exist on the Missouri river, and in the interior of the state. In Washington county, Belvue settlement, in addition to lead, says Mr. Schoolcraft, "in the richness of the ore, and extent of the beds or mines, it is no where paralleled. The most noted place is the iron mountain, where the ore is piled in such enormous masses, as to constitute the entire southern extremity of a lofty ridge, which is elevated 500 or 600 feet above the plain." Water power to work this mass abounds in all directions. It is, however, only one of a number of mines of this really most precious of all metallic bodies, which lie scattered over the sources of St. Francis and Merrimack rivers.

In the same vicinity, and in fact over the entire lead tract, ores of zinc abound, a very important fact in the mineralogy of Missouri. Zinc is, when it can be cheaply procured, one of the most useful metals, answering nearly all the purposes, without the destructive qualities of copper. Zinc has been hitherto considered a scarce ore, and should it be found in large bodies in the Mississippi basin, will add a very important article to the resources of that fine region.

The most singular circumstance in the mineralogical history of the interior of North America, is the abundance and extent of the stores of muriate of soda, common salt. Amongst the revolutions effected in the last forty years on the condition of society, there is none more salutary to private convenience than the change in the price of salt in the interior of this continent. We remember, when the supply for west Pennsylvania and west Virginia was procured by transportation from the Atlantic slope. At a period when money was at least 100 per cent. above its present value, salt cost in those places five dollars per bushel, at a *minimum* price. It is now manufactured in a great variety of places, where the face of the earth gave no indications of its existence.

There is good reason to believe, that at certain depths, the whole basin of the Mississippi is saturated with salt water; a fact which, combined with the abundant existence of limpid fresh water at the surface, is highly consolatory.

Where muriate of soda prevails to such excess, as in some parts of the Spanish internal provinces, the earth becomes uninhabitable, cold, and steril. This is also the case with part of central Asia. In Europe, salt is procured generally from the sea, or found in substance in mines, as at Guadaloupe in Spain, and more particularly Wielitzka, near Cracow, in Austrian Poland. In North America, this mineral has not been found in solid imbedded masses, though no reasonable doubt can be entertained, but that the bowels of the earth must contain prodigious bodies of that fossil in its crystallized state, in places where it is so very extensively held in solution by water. It may be safely expected, that in some future day, muriate of soda will be quarried in the Mississippi basin, as in Spain and Poland.

Coal has been mentioned amongst the mineral products of Missouri; but we are unacquainted with any extensive body of that fossil yet brought into use in that state. Mr. Bradbury speaks with enthusiasm of the enormous strata of both coal and iron, which lines many parts of the banks of Missouri; but the coal spoken of by this author is generally above the limits of Missouri.

Many other mineral substances of less value have been discovered in Missouri; but so much of the area of the state remains unsettled, that its mineral and vegetable wealth have only commenced their development. From what is known, much may be expected; few sections of the earth, of equal superficies, and of so recent civilized colonization, have exhibited so rich a variety of mineral resources as southern Missouri.

This state is in a peculiar degree remarkable, as forming the connecting link between the forest and meadow or prairie sections of North America. That enormous forest, which we have remarked as covering the entire Atlantic slope, nine-tenths of St. Lawrence basin, all the basins of Appalachicola and Mobile, all the Delta of the Mississippi, and most parts of the left side of its basin, reaches into Missouri, and covers nearly all its southern and south-eastern sections. This great body of woods is indented in Ohio, Indiana, and Illinois, by a protrusion of the prairies, which expand advancing south-west, and range through Missouri south of Missouri river. On the west border of that state, on the Osage, and near the junction of the Missouri and Kanses rivers, the prairies usurp much the greater share of the surface of the whole country. Lines of woodland follow the streams, leaving the intermediate spaces open plains. Those lines of timbered ground gradually become more attenuated westward, until nearly one unbroken waste spreads over hundreds of miles. The peninsula between Missouri and Mississippi rivers, though not so naked of timber as are the sources of Arkansaw, Kanses, and Platte rivers, yet immense prairies occur on the former region also. Over an extent much more than equal to the inhabited parts of the United States and Canada, the winds of the north, west, and south-west breathe over Missouri, without much impediment from mountains, hills, or forests. It will be seen in the sequel, that from this exposure arises the peculiar variable and cold climate, which prevails near the junction of the Mississippi and Missouri rivers. If due attention is paid to the physiognomy of the adjacent regions, it will at once be seen, that the surface of Missouri is in a peculiar manner liable to extraneous influence. To the south-west, for upwards of twelve hundred miles, expands a dry salt desert. To the west, as far as known, the extension of the same desert leaves the earth a void. To the north-west, a two-fold cause superinduces a flux of cold air over Missouri. The openness of the immense regions in that direction, and the constant volumes of cold, and often frozen water, brought down by the Mississippi and Missouri rivers. It is from these combined causes that such excessive changes are felt, and inequalities of seasons experienced, to extremes scarcely known in any other spot on this planet. It is from this complicated climate, that in N. Lat. 38° 30′, the rivers are frozen, four years in five, before the end of December. Another phenomenon has been observed in Missouri, which in a striking manner distinguishes its seasons from those of Louisiana or the Atlantic slope; that is, the much less moisture in the atmosphere of the former. Though frosts are so rigorous at St. Louis as to render the Mississippi passable on the ice before the beginning of January in ordinary seasons, yet deep snow or drenching rains are uncommon. The air is commonly dry, cold, and elastic. In reality, the position of Missouri, Arkansaw, and Louisiana, are all singularly worthy of philosophic attention. A dense forest covers all the alluvial bottoms of the Mississippi, and those of its confluents. On the east side of that vast recipient, we have seen this forest only terminated by the Atlantic ocean. On the west, it is followed by the prairies or desert we have noticed. Moisture is as remarkably abundant in the forest tracts, as it is wanting in that of the prairies. The natural consequence of the position of places, on the confines of two regions whose meteorological constitutions are so essentially different, is an exposure to the extremes of both, following the current of air. This is, in an extraordinary degree, the case with Louisiana, where two successive seasons may differ so much, as one to present an almost constant deluge of rain, and the other scarcely affording a single shower. Ascending the Mississippi, the quantity of rain becomes less in a given time, at least as far north as 45°.

A remark may be made in this place, that what may be designated the rainy and dry seasons, are not confined to the tropics. Rain and snow are mere relative terms, therefore, in the United States. The rainy and dry seasons are nearly as regular in their succession and periods, as similar seasons are within the tropics. The difference is rather in the quantity, than in the times of rain and fair weather. To this theory, Louisiana is the most remarkable exception; and when viewed in connection with the adjacent and distant regions, the causes of the aberrations of the seasons of that state, are at once perceived, and clearly understood. It ought, however, to be recollected, that we are now making a natural, and not a political survey; therefore, in specifying Louisiana, the Delta of the Mississippi and contiguous places are meant. It is when making such expansive surveys, and elucidating the phenomena of nature on so large a scale, that the full value of maps can be fully appreciated. Without maps, no enlarged views of the laws of meteorology could ever be formed by any exertion of the human intellect; and it is from neglect of such comprehensive combinations, that so many crude notions on particular climates pass current.

Climate, Seasons, and Productions.—After what has been given in this article, little can be added on these heads.

The climate of Missouri is liable to great extremes of heat and cold. The winters at St. Louis are severe; the Mississippi, in ordinary seasons, being frozen before the end of December. The illimitable plains to the south-west and west of the state, leave an open vent to the winds, and superinduce a much greater severity of cold in a given latitude than on the Atlantic coast.

The seasons of Missouri partake of the unsteady character of the climate of the Mississippi basin, and indeed of the continent of North America in general. No two seasons in succession have much resemblance to each other. The occurrence of first frost in autumn, the last in spring, or the quantity and times of rain and snow in winter, are equally uncertain.

In one respect, the climate of Missouri differs essentially from that on the Atlantic slope in similar latitudes: as we before observed, less moisture falls on the former than on the latter, either as rain or snow. This circumstance has misled many as to the real nature of the climate of Missouri, and has given to it a character of mildness, the reverse of the fact.

The productions of Missouri have been noticed, both vegetable and metallic. We may merely add, that the vegetables usually cultivated, are those found in the middle states generally.

In metallic and other fossil substances, Missouri is perhaps the richest region in the United States. The following catalogue, given by Mr. Schoolcraft, yields a result, which strongly illustrates the mineral wealth of the state of Missouri, where most of these substances are found.

Metallic Substances.

Native iron,	Iron sand,
Red oxyd of iron,	Native magnet,

Argillaceous oxyd of iron,	Granular sulphuret of lead,
Micaceous oxyd of iron,	Earthy oxyd of lead,
Iron pyrites,	Carbonate of lead,
Brown hematite,	Sulphuret of antimony,
Sulphuret of zinc,	Black oxyd of manganese,
Sulphate of zinc,	Native copper,
Sulphuret of lead,	Sulphate of copper.

Saline Substances.

Nitrate of potash,	Sulphate of magnesia,
Muriate of soda,	Native alum.

Inflammable and Miscellaneous Substances.

Sulphur,	Madrepore,
Stone-coal,	Graphite.
Pumice,	

Earthy Substances.

Chalk,	Plastic white clay,
Flint,	Fullers' earth,
Hornestone,	Stalactite,
Rock-crystal,	Stalagmite,
Novaculite,	Pudding-stone,
Common quartz,	Opal,
Citrine,	Jasper,
Radiated quartz,	Agatized wood,
Red ferruginous quartz,	Carnelian,
Granular quartz,	Sulphate of lime,
Tabular quartz,	Feldspar,
Hoary quartz,	Calcareous spar,
Steatite,	Basanite,
Mica,	Buhrstone,
Chalcedony,	Onyx agate,
Reddle,	Greenstone porphyry,
Yellow earth,	Schorl,
Opalized wood,	Ochre,
Agaric mineral,	Shale.

To the above may be added carbonate of lime, in form of limestone, and marble.

The lead-mines of Missouri are principally in the county of Washington, but there are also diggings in St. Genevieve, Madison, and Jefferson counties.

The ore is that species called galena, by mineralogists; the sulphuret of lead, of chemistry. The ore yields about 80 per cent. of pure lead. The mass seems inexhaustible, but very irregularly disposed, the veins having no stratification, but branch through the other substances in every direction, and an indefinite thickness. Taken as a whole, the lead district of the state of Missouri is the richest in the production of that metal of any ever discovered.

Counties and Historical Epocha.—Bounded on the Missouri and the Mississippi, and occupying the north and west sections of the state, are the counties:

	Chief Towns.
St. Louis,	St. Louis.
Franklin,	Franklin.
Cooper,	
Howard,	
St. Charles,	St. Charles.
Montgomery,	
Pike,	
Lincoln.	

Those counties lying along the territory of Arkansaw south, and along the banks of the Mississippi east, are:

	Chief Towns.
Lawrence,	
New Madrid,	New Madrid.
Cape Girardeau,	Cape Girardeau.
Wayne.	

The mining district contains the central counties of

	Chief Towns.
St. Genevieve,	St. Genevieve.
Madison,	Fredericktown.
Jefferson,	Herculaneum, or St. Michael.
Washington,	Caledonia.

The lead mines of the state of Missouri deserve some historical notice, from their immensity and national importance.

The West Company was formed by letters patent under the regency of the duke of Orleans, during the minority of the king of France, Louis XV.; dated the 23d of August, 1717, and enregistered the 6th of September following.

Under this company, came out to Louisiana in 1719, Philip Francis Renault, son of Philip Renault, a noted ironfounder at Consobre, near Manberge, in France.

In 1720, Renault and one of his associates, a M. La Motte, discovered the respective mines which bear their names.

Renault worked the mines extensively, but was in the end obliged to abandon the undertaking, from some fiscal arrangements in France, and returned to his native country in 1742. From that period until 1797, or during the long period of 55 years, no attempts of any consequence were made to smelt lead in these neglected mines.

In 1797, a Moses Austin, Esq. from Wythe county in Virginia, made a journey to the lead mines in Louisiana, and obtained a patent from the Spanish authorities for one league square, in consideration of erecting a reverberatory furnace. This work was commenced in 1798. Mr. Austin sunk the first regular shaft for raising the ore.

In 1799, this gentleman erected a shot tower, and made shot of approved quality. The latter work was erected under the superintendance of Elias Bates. Since the foregoing period, the lead-mines have continued to attract public attention, and have been extensively worked. When Mr. Schoolcraft visited this tract in 1818, he enumerated forty-five diggings.

What is now the state of Missouri formed a part of Louisiana, and has underwent the political revolutions of that country, and was amongst the first parts that the French discovered. In 1674, two Missionaries, by the names of Jolliet and Marquette, entered the Mississippi by the route of Ouisconsin, descended the former stream to the Arkansaw, and returned to Canada by the Illinois. The country was visited by M. de la Salle in 1683. Some settlements were made soon after in the respective regions now comprised in the state of Illinois and territory of Arkansaw, but none in any part now within the state of Missouri.

In 1762, all Louisiana was ceded by France to Spain, and possession taken in 1769.

Upper Louisiana, now state of Missouri, began to be peopled about 1760. The attempt of settlement at the mines by Renault, and its failure, we have seen. In 1762, the present town of St. Louis was commenced, since which period settlements have gradually, but, during the existence of the Spanish government, slowly advanced. In 1803, this country, with all Louisiana, was ceded to the United States; and, early in 1804, was taken possession of by Major Amos Stoddard.

Louisiana was divided into two territories, that of Orleans below N. Lat. 31°, and Louisiana, containing the residue of that country. New Orleans continued the capital of Orleans, and St. Louis, of Louisiana.

In 1810, the then territory of Louisiana contained 20,845 inhabitants, of which 3011 were slaves.

In 1812, when the territory of Orleans became the state of Louisiana, Louisiana territory was changed to the territory of Missouri; and, on the 4th of January, 1813, Mr. Edward Hamstead took his seat in Congress, as delegate. April 3d, 1818, the bill for the admission of Missouri into the Union as a state received the second reading, and was committed.

On the bill being brought up for a third reading, its passage was opposed, unless under condition of prohibiting the introduction of Negro slaves. This opposition defeated the bill in the session of 1818—19, and in the session of 1819—20, both of which, particularly the latter, was in great part consumed in debates on the subject. In the former session, March 6th, 1820, an act was passed permitting the people of Missouri to elect a convention, which was empowered to frame a constitution, and adopt such name as they should choose; and under such constitution, when approved by Congress, such state to become one of the United States, with all the rights and immunities appertaining to the original states.

The convention of Missouri met at St. Louis, ——— 1820, and formed a constitution, which was presented to Congress for approval, at the opening of the session of 1820—21. A clause in the constitution, excluding from the state free negroes and people of colour, gave rise to a long and violent debate in both houses, which eventuated in a resolution of Congress, dated March 2d, 1821, in the following terms.

"*Resolved by the Senate and House of Representatives of the United States of America in Congress assembled*, That Missouri shall be admitted into this Union on an equal footing with the original states, in all respects whatever, upon the fundamental condition, that the fourth clause of the twenty-sixth section of the third article of the constitution submitted on the part of said state to Congress, shall never be construed to authorize the passage of any law, and that no law shall be passed in conformity thereto, by which any citizen of either of the states in this Union, shall be excluded from the enjoyment of any of the privileges and immunities to which such citizen is entitled under the constitution of the United States: *Provided*, That the legislature of the said state, by a solemn public act, shall declare the assent of the said state to the said fundamental condition, and shall transmit to the President of the United States, on or before the fourth Monday in November next, an authentic copy of the said act; upon the receipt whereof, the President, by proclamation, shall announce the fact: whereupon, and without any further proceeding on the part of Congress, the admission of the said state into this Union, shall be considered as complete."

The legislature of Missouri, on the 26th of June, 1821, passed an act of accession to the conditions contained in the foregoing resolution of Congress, and transmitted the act to the President of the United States, who, on the 10th day of August, 1821, issued his proclamation pursuant to the tenor of the resolution of Congress, and the accession of the legislature of Missouri to its provisions, and Missouri became a state of the United States.

It may not be uninteresting to trace the line, which, by the act of admission of Missouri, bounds the slave-holding from the non-slave-holding states and territories that have been, or may be formed beyond the Mississippi. Beginning on the right bank of that stream, at the mouth of Ohio, and following the boundaries of the state of Missouri up the Mississippi and Lemoine rivers, and thence to the south-west angle of Missouri, on the north boundary of Arkansaw territory, at N. Lat. 36° 30′; and thence due west to the frontier line between the United States and Spain.

DARBY.

MITHRIDATES. See ROME.

MITYLENE. See METELIN.

MNEMONICS (*ars mnemonica*, from the Greek *μνημων*, *memor*,) signifies, in the more general sense of the word, the laws which regulate the exercise of the faculty of memory; in its more limited signification, it means a system of rules to assist the memory, by means of association, in recalling past impressions. Such a system was called by the ancients *memoria artificialis*, to distinguish it from a naturally good memory, unassisted by technical rules.

There is no doubt that the memory is a faculty highly susceptible of cultivation, and also very capable of being assisted, in many cases, by arrangement and association. We have numerous instances, indeed, both in ancient and modern times, of individuals who possessed and exercised this faculty in a very extraordinary degree; but we are frequently left in doubt whether they depended entirely on the natural strength of an originally good memory, improved, perhaps, by regular and assiduous cultivation; or whether they had recourse to some mechanical aids. Cyneas, who was sent by King Pyrrhus on an embassy to the Romans, learnt, in the course of one day, the names of all those persons whom he had seen so perfectly, that, on the following day, he could name all the members of the senate, and all the Romans who had assembled round them. King Cyrus could name all the soldiers in his army; and L. Scipio all the citizens of Rome. Mithridates, the king of two and twenty nations, held courts in as many languages, and could converse with each nation in its own tongue, without using an interpreter. Themistocles is said to have been oppressed by the strength and tenacity of his memory; and in the course of a year he learnt to speak Persic with perfect propriety. Crassus, while governor of Asia, learnt the five Greek dialects so completely, that he was able to give judgment in each. Hortensius, the Roman orator, was able to repeat a whole oration in the words he had previously conceived it, without committing it to writing; and to go through the whole arguments of an opponent in their proper order. It is said, that he once attended a whole day at a public sale, and, at the end of it, recited, in regular order, the names of all the buyers, the articles sold, and their prices, with perfect exactness. Seneca, in his youth, could pronounce two thousand given words in their proper order; and having got a verse from each of his school-fellows, he repeated more than two hundred of them from the bottom to the top. Avicenna could with facility repeat the whole books of Aristotle's metaphysics. Picus de Mirandola repeated two thousand names which had been read over to him. Joseph Scaliger, when a young man, could repeat above one hundred verses, having once read them; and, in the course of a few weeks, he could repeat the contents of whole books in foreign languages. Magliabechi dictated, from memory, whole books which had been lost. Several individuals are said to have been able to repeat the contents of entire books from the end to the beginning, as is reported of the German poet Klopstock, with respect to Homer, when he was at the school of Porta. William Lyon, a travelling player, repeated the contents of a newspaper from beginning to end. An Englishman once came to Frederick the Great of Prussia, for the purpose of giving him some specimens of his extraordinary memory. Frederick sent for Voltaire, who read to his majesty a pretty long poem which he had just finished. The Englishman was concealed in such a manner as to be able to hear every word that was said. When Voltaire had concluded, Frederick observed that a foreign gentleman would immediately repeat the same poem to him, and therefore it could not be original. Voltaire listened with astonishment to the stranger's declamation, and then fell into a great rage, and tore the manuscript in pieces. When Frederick informed him of his mistake, the Englishman again dictated to Voltaire the whole poem with perfect correctness.

These instances are sufficiently remarkable, even after making every reasonable allowance for exaggeration. But there is a story told by Antonius Muretus, respecting the wonderful memory of a young Corsican, which is still more astonishing. We shall relate the story nearly in his own words. "At Padua there dwelt, not far from me, a young Corsican, who was believed to be of a good family. He had come thither in order to learn the civil law, and had devoted himself, for several years, to this study, with such diligence and success, that we all began to entertain a high opinion of his learning. During one summer, he came almost every evening to my house. He was reported to be in possession of an art of memory, by means of which he could perform things which no one could believe without being an eye-witness. I had scarcely learnt this when I became desirous of seeing some of these wonders; and my wish was soon gratified. I told him that, in return for my hospitality, I conceived I had a right to ask to see a specimen of his art, if it were attended with no inconvenience to himself. He answered immediately, and without taking time to reflect, that he would willingly comply, as soon as I should desire it. We went directly into an adjoining room, and sat down. I dictated to him words from the Latin, Greek, and other languages, with which he was less familiar, sometimes with and sometimes without meaning, so different, so unconnected, and in such number, that I was abundantly fatigued with dictating, the boy who took down the words with writing, and the other persons present, with hearing and expectation of the result. He alone, still cheerful and unexhausted, always called for more. I told him, however, that every thing must have its due measure and limits, and that I should be perfectly satisfied if he could repeat but the one half of what I had dictated. He then stood for some time silent, with his eyes fixed upon the ground, while we were all full of expectation. At length this wonderful man began to speak; and he repeated, to our astonishment, every thing in the very same order, and without the slightest embarrassment or hesitation. He then began with the last word, and repeated backwards to the first; and he afterwards repeated the first, third, fifth word, &c. or in any other given order. I afterwards became better acquainted with him, and found, after many trials, that there was no quackery in his system. He once assured me (and he was the greatest enemy of all boasting) that he could, in the same manner, repeat 36 000 (others read only 6.000) words. But what is most remarkable, every thing was so firmly impressed on his memory, that, as he asserted, he could without difficulty remember whatever he had committed to it after a lapse of years; and this assertion I found to be true, upon making a trial some considerable time afterwards. But farther: There dwelt with me Franciscus Molinus, a patrician of Venice, who was exceedingly ardent in the study of the sciences. Impressed with the feeling of the weakness of his memory, he entreated the Corsican to teach him his art, to which the latter immediately consented. A place and hour were accordingly fixed for their daily meetings; and in the course of six or seven days the scholar could repeat, without difficulty, more than five hundred words, in the same, or any other given order." Muretus adds, "I should not have ventured to relate all this, lest I should be suspected of a falsehood, if the facts had not been quite recent, and capable of being attested by a number of witnesses. The Corsican asserted that he had learnt this art from a Frenchman, who had been his tutor." Gisbert Voetius, a reformed divine of the seventeenth century, considers the performance of this Corsican as a proof of his intercourse with the devil.

The astonishing powers of calculation possessed by Jedediah Buxton, a man otherwise illiterate, are well known; and many of us have had a recent opportunity of witnessing a similar phenomenon, in the person of Zerah Colburn, an American boy, under eight years of age, who exhibited in London and Edinburgh some years ago, and who, without any previous knowledge of the common rules of arithmetic, or even of the use and power of the Arabic numerals, and without having given any particular attention to the subject, was found to possess, as if by intuition, the singular faculty of solving a great variety of arithmetical questions by the mere operation of the mind, and without the usual assistance of any visible symbol or contrivance.*

We might quote various other instances of individuals who possessed extraordinary powers of memory, but it is unnecessary to multiply examples. We proceed, therefore, to notice the traditional origin of the mnemonic art, as mentioned in the Parian Chronicle, as well as by Cicero and Quintilian, and other ancient authors. And here we shall avail ourselves of the labours of the late Professor Barron, who, in his *Lectures*, has entered pretty fully into the discussion of this subject.

The principal expedient for assisting the memory is

* George Bidder, a boy from Devonshire, has exhibited powers of calculation not inferior to those of Zerah Colburn. He is now educating in Edinburgh, under the patronage of Henry Jardine, Esq. See the *Edinburgh Philosophical Journal*, Vol. II. p. 193.—Ed.

derived from association. For instance, when I see a house, I naturally recollect the inhabitants, their manner of life, and the intercourse I have had with them. The sight of a book prompts the memory of its contents, and the pleasure or profit I have received from the perusal of it. A view of the sea may suggest the idea of a storm; and the painful recollection of the loss of property, or of the life of a friend, by shipwreck. The act, then, of aiding recollection by association, is to connect thoughts remote or abstract, with others more obvious and familiar, that the recurrence of the latter may bring along with it the memory of the former. Thus, the sight of my ring, which I cannot miss to observe, reminds me of the action, to suggest the remembrance of which I removed it from one finger to another. The ringing of the bell, or the sounding of the clock, prompts the recollection of the business I had resolved to perform at these times. A glimpse of the first words of a paragraph, or a page, introduces the recollection of the whole. In a word, we must connect the things we wish to remember with the immediate objects of our senses, that offer themselves daily to our attention, but particularly with the objects of our sight, the most vigorous and lively of all our senses, and of which the objects are perhaps more numerous than those of all our other senses put together.

This theory is the foundation of all contrivances which have been, or perhaps can be, employed to help recollection. It is the groundwork of the famous artificial memory of Simonides, a lyric poet, who is celebrated by Cicero and Quintilian as the inventor of mnemonics. Both these authors relate the following mythological incident, on the occasion which suggested the invention. Simonides was employed by Scopas, a rich Thessalian, to compose a panegyric on him for a certain sum of money; was invited to a festival, given by Scopas to his friends, in order to rehearse it, but was sordidly refused more than half the stipulated compensation; because, puzzled perhaps with the sterility of the principal subject, he had introduced a long episode in praise of Castor and Pollux. Simonides was soon after summoned from the company by two young men on horseback, supposed to be Castor and Pollux in disguise, who, as soon as they had saved their favourite poet, made the roof fall on Scopas and his company, bruising them to death, that not a lineament of them could be known. Simonides, however, by recollecting the order in which they sat at table, was enabled to distinguish them, and to deliver them to their friends for burial. The aid which the recollection of the poet received, on this occasion, is said to have suggested the idea of an artificial memory.

The principle of the scheme of Simonides is, to transfer a train of ideas, the archetypes of which are not the objects of sense, and are, therefore, of difficult recollection, to another train which we cannot fail to recollect, because the archetypes are not only objects of sense, but objects of sight, with which archetypes we are perfectly familiar, or which may be placed actually before our eyes. Suppose then Simonides were to commit to memory a discourse consisting of speculations concerning government, finances, naval affairs, or wisdom, none of the archetypes of which could be made objects of sense, at least, at the time of delivery; and to assist his recollection, he were to connect the series of ideas, in that discourse, with a series of objects, which he could either place in sight, or with which he was so familiar that he could not fail to recollect them; he would proceed in the following manner: He would take a house, for instance, either the one in which he might deliver the discourse, or another; with every part of which he was perfectly acquainted. He would begin at some fixed point of that house, suppose the right side of the door, and he would proceed round it in a circular line, till he arrived at the point from which he set out. He would divide the circumference of the house into as many parts as there were different topics or paragraphs in the discourse. He would distinguish each paragraph by some symbol of the subject it contained; that on government by the symbol of a crown, or a sceptre; that on finances, by the symbol of some current coin; that on naval affairs, by the figure of a ship; that on wisdom, by the figure of the goddess who presided over it. He would either actually transfer, or suppose transferred, these symbols to the different compartments of the house, and then all he had to do, in order to recollect the subject of any paragraph, was, either to cast his eye on the symbol during delivery, or to remember upon what division the symbol was placed. The memory, by this contrivance, easily recalled the discourse. The orator either saw, or could not fail to remember the compartments, because he was perfectly familiar with them. Neither could he forget the symbols of each paragraph, because they were no more than hieroglyphical paintings of the sense.

Such were the origin and principles of the celebrated topical memory of the ancients; from which source are derived all the various modern systems of local and symbolical memory. Our readers will find this story of Simonides circumstantially related and commented on by Cicero, *de Orat.* lib. ii.; by the author of the books *ad Herennium*, lib. iii.; and by Quintilian in the second chapter of the eleventh book of his Institutions. The Anthology has preserved the following distich of Simonides, relative to the subject of his memory:

Μνημην δ'ȣ τινα φημι Σιμωνιδη ισοφαριζειν
Ογδωκοντα ετει παιδι λεωπρεπεος.

Nemo magis memor est Simonide, conscius aio
Cui sex et fuerant lustra peracta decem.

We must observe, however, that in spite of these ancient authorities, the claim of Simonides to the merit of inventing the art of memory, has been recently controverted in a dissertation on the mnemonic art among the ancients, by Professor Morgenstern of Dorpat, who seems to trace this science to the Egyptian hieroglyphics.

Several of the Greek philosophers appear to have adopted and recommended certain artificial rules for the assistance of the memory; Aristotle is said, among others, to have written a work entitled *Μνημονικον*, which has been lost; and Pliny (*Hist. Nat. Lib.* VII. *cap.* 24.) expressly names Metrodorus, a contemporary of Cicero, as the individual who first brought the art into a systematic and scientific form. It is to him, therefore, that we are probably indebted for the theory of places and images.

In more modern times, this art was cultivated by Raymund Lully, (in his *Ars Magna*,) and others, whose works we shall notice at the end of this article. The Germans, who are fond of constructing theories upon all subjects, have recently paid much attention to mnemonics, and have not only explained the ancient methods, but invented several new systems.

So early as towards the end of the 16th century, the art of memory was revived by Lambert Schenckel, a man who possessed considerable learning, and who wrote various works on grammar, prosody, rhetoric, &c. He travelled for many years in Germany, the Netherlands, and France; and he obtained from the University of Paris the privilege of teaching his mnemonic doctrines in that capital. In his old age, he appointed his friend and pupil, Martin Sommer, a Silesian, to be his successor in the mnemonic chair. Sommer published a short tract in Latin, by way of invitation to the study of his art. Like his master, Schenckel, he travelled a great deal, and realised a considerable fortune by teaching. Schenckel's work on the art of memory appeared, for the first time, in 1610; and Sommer published a new edition of it in 1619. For a long period, the principles of Lullus and Schenckel continued to be studied and commented upon, but little accession was made to the doctrine of mnemonics; on the contrary, the speculations on this subject degenerated so much into frivolous commonplace, or mystical jargon, that they tended rather to degrade than to promote the study of the art.

The principal work published in England, on the subject of the local memory, appeared in 1618, under the title of *Mnemonica; sive ars reminiscendi*, &c. by John Willis; and was translated, in 1661, by one Sowersby, a bookseller. In the year 1651, Henry Herdson published his *Ars Mnemonica, sive Herdsonus Bruxiatus*, &c. in Latin and English. It is merely a republication of part of Brux's *Simonides Redivivus*. The *Memoria Technica* of Richard Grey was published in 1730; and to the ninth edition are appended the *Mnemonics* of Solomon Lowe, a small tract, now exceedingly rare, which was first published in 1737. The system of Dr. Grey is allowed to be very ingenious. Dr. Priestley observes, "It is so easily learned, and may be of so much use in recollecting dates, when other methods are not at hand, that he thinks all persons of a liberal education inexcusable, who will not take the small degree of pains that is necessary to make themselves masters of it; or who think any thing mean, or unworthy of their notice, which is so useful and convenient."

Since the commencement of the present century, the mnemonic doctrine has been again revived on the Continent, with considerable success, by Gräffe, Aretin, Duchet, Kästner, Feinaigle, and others. Feinaigle travelled a good deal; and some years ago, he taught, and exhibited specimens of his method, at Paris, London, and Edinburgh. A small volume was afterwards published, illustrative of the principles of his system, and exhibiting their application to the various sciences; from which we shall endeavour to present our readers with an abridged account of his method.

Locality, it is observed, is the most efficacious medium of reminiscence; and that system of memory will be the most serviceable which brings this principle into the most extensive operation. For this reason, *locality*, or the connection of our ideas with places, is made the foundation of the present system.

A room having generally four walls, the most obvious division of it is into four sides, and each wall or side may be subdivided into pannels or compartments. Accordingly, the ancient system divided a wall into five spaces; and this plan was applied to as many rooms as were found necessary to the extent of each particular scheme —every room being similarly divided into four sides, and every side being subdivided into five compartments. Thus, any idea which, according to this method, had been associated in the mind with the forty-eighth compartment, would be placed in the third compartment of the second wall, in the third room. But, as few compartments could be obtained on each wall by these means, the calculation of high numbers would be exceedingly difficult. To remedy this defect, each wall might be divided into nine or ten compartments. If a wall be divided into nine parts, there will be 36 compartments in every room. In order to ascertain the situation of any particular number, it is to be considered in relation to the total number of the subdivisions. For example, if the situation of number 48 be required; according to the last mentioned division of the rooms, it is to be found by considering the proportion which that number bears to 36, the total number of the compartments in this arrangement. If the number in question be less than this total, the place inquired after will be obvious; thus, 12 being within the number 36, must, of necessity, be in the first room; being above 9, it is equally clear that in cannot be on the first wall, and being less than 18, it must, necessarily, be in some part of the second wall; and as it exceeds the number of the first wall by 3, it follows, of course, that its place must be in the third compartment of the second wall. If the number in question be higher than the number of the compartments in one room, its place will be readily found by dividing it by that number. Thus, suppose 48 to be the number whose place is required:

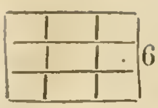
```
36)48(1.2
   —
 9)12(1.2
   —
    3
```

As 48 exceeds 36, we know that it cannot be in the first room, the 1 is therefore changed into two; and the fraction remaining shews it to be in the twelfth compartment. There being nine compartments in every wall, this remainder, or number of the compartments, is divided by 9, for the purpose of ascertaining the wall. Now, as the divisor is contained more than once, but not twice, in the dividend, it follows, that the compartment sought must be on the second wall; the remainder gives the specific compartment. This operation, then, shews that 48 is in the third compartment, on the second wall, in the second room. This was the plan adopted by the ancients, when they divided their rooms into parts; but being both complicated and difficult, Mr. Feinaigle has rejected it in his system; and another scheme has been introduced in its place, which he conceives to be more simple in its construction, less difficult in its application, and much more extensive in its powers.

He divides a wall in the following manner:

1	2	3
4	5	6
7	8	9

These figures are arranged from left to right, in the usual manner of writing; and for the more easily remembering their situation, it will be found, that if two lines be drawn diagonally from the four corners of the figure, they will intersect all the odd numbers. The nine squares, or compartments, are termed *places*, and are called first place, second place, &c. The same mode must be pursued with the three remaining walls in this room, by which means four walls are obtained, each divided into nine *places*. In order to find the number 36 in this room, we should naturally say four times nine will be 36, and should, of course, conclude that 36 would be in the last place of the last side or fourth wall of the room. But this calculation is erroneous; 6 must ever be in the same situation, which will be that occupied by the point in the following figure:



And the numbers 16, 26 and 36, will be in the corresponding situation on their respective walls.

It must now be determined, how we are to reckon these walls. If we stand in a room with our back to the windows, the first wall is on our left, the second before us, the third on our right, and the fourth behind us. We shall, however, commence with the floor, and divide it into nine parts, in the same manner as the walls. Where are 10, 20, 30. &c. to be placed? Every decade begins a new series, and the decimal is placed on the ceiling of the room over its proper wall; thus the first decimal, or 10, will be over the first wall; the second decimal, or 20, over the second wall, &c.; and the fifth decimal, or 50, as its tenth-part exceeds the number of walls, will be assigned to the ceiling of the room, and will consequently be the highest number in the first room, forming the connecting link between this room and the second. When a second room is taken, the floor of it is denominated the fifth wall, the wall on the left the sixth, &c., and as the number 50 was upon the ceiling of the first, so the number 100 will be upon the ceiling of the second room.

In order to remember a series of words, they are put in the several squares or places, and the recollection of them is assisted by associating some idea of relation between the objects and their situation; and, as we find by experience, that whatever is ludicrous is calculated to make a strong impression upon the mind, the more ridiculous the association the better. To illustrate this idea, Mr. Feinaigle places the names of certain sensible objects in the different compartments, and connects the ideas of their images by some story, so as to make it almost impossible to forget the order in which they are arranged.

Another part of Mr. Feinaigle's system is the converting figures into letters,—a branch of the mnemonic art which has been adverted to, we believe, by almost every writer on the subject. Mr. Feinaigle uses the consonants only, one or more of which are attached to the series of figures, each figure having its appropriate consonant. The letters appropriated to the figures are selected on account of some real or supposed resemblance. These letters, and the figures which they are intended to represent, should be strongly impressed upon the memory, as the letters must be converted into words by the introduction of vowels. The two consonants representing two figures must be converted into a word, to which should be affixed some striking idea; and the images represented connected together. The objects, when selected, each being a word, must be arranged in the different *places*, beginning with the floor, and proceeding to the first, second, and third walls, &c. In making these words, it is necessary that the two consonants required should be the two *first* in the word; if there be more than two, it is of no importance, as the two first only will be needful. The converting of figures into letters, and making sense by the introduction of vowels, will be found applicable to many of the purposes of common life.

Mr. Feinaigle proceeds to observe, that if the reader has practised the instructions already given in a room in which he is accustomed to spend the greater part of his time, and this room should have been hung with pictures, engravings, &c., he will have been very materially assisted in the remembrance of his *places* or localities. The transition is slight, but the impression is permanent. Let us, says he, fill the squares or places with some pictures of our own drawing; the two rooms will be then furnished, and it will be as easy to remember the symbols or hieroglyphics, as to remember the situation or place of any picture, or article of furniture, in a room. Mr. Feinaigle has, accordingly, illustrated this part of his system by some tables of symbols, and some diagrams, for which we must refer the reader to the book itself; as it has been our object rather to give an outline of his principles than a full exposition of his method. For the same reason, we deem it unnecessary to accompany the learned professor in his application of these principles to the various sciences.

We have already admitted the possibility of giving great assistance to the memory by means of arrangement and association. It appears to us, however, that the apparatus of most of the systems hitherto proposed with that view is a great deal too complicated; and that a method might be devised much more simple in its elements, more easy of acquisition, and equally well adapted to all purposes of real utility.

The following are the principal works which have been written on the subject of mnemonics: *The Castel of Memorie*, &c. *made by Gulielmus Gratarolus; Englyshed by William Fulwood.* (Black letter.) Gratarolì's treatise on the Memory was also translated into French by Stephen Cope; Lyons, 1586. Jordano Bruno, *De Imaginum et idearum compositione ad omnium inventionem, et Memoriæ genera tres libri;* Franc. 1591, 8vo. *Ars Reminiscendi Joan. Baptistæ Portæ Neapolitani;* Naples, 1602, 4to. Lambert Schenckel, *Methodus de Latina Lingua intra 6 mensis docenda*, Strasburgh, 1609, 8vo. Ejusd. *Gazophylacium Artis Memoriæ*. &c. Ibid. 1610, 8vo. Various other works were published in illustration of Schenckel's method. *Simonides redivivus*, &c. *Authore Adam Bruxio;* Leipsic, 1610, 4to. *F. M. Ravellini Ars Memoriæ*, &c. Franc. 1617. 8vo. John Willis, *Mnemonica*. &c. London, 1618. This book was translated into English by one Sowersby, London, 1661. *Ars Memoriæ localis*, &c. Leipsic, 1620, 8vo. Adrian le Cuirot, *Magazin des Sciences, ou vray l'art de Memoire;* Paris. 1623, 12mo. Henry Herdson, *Ars Mnemonica*. &c. in Latin, and *Ars Memoriæ; The Art of Memory made plaine*, in English; both tracts published at London, 1651, 8vo. Jean Belot, *L'Oeuvre des Oeuvres*, &c. Lyons, 1654, 8vo. Athanasius Kircher, *Ars Magna Sciendi*, &c. Amsterdam, 1969, fol. *The Divine Art of Memory*, &c. translated from the Latin of the Rev. John Shaw, by Simon Wastel, Lond 1683, 12mo. Buffier, le Pere, *Pratique de la Memorie Artificielle*, &c. Paris, 1719—1723, 3 vols 8vo. *Memoria Technica*, &c. by Richard Grey, D D. London 1730, 8vo. Solomon Lowe, *Mnemonics Delineated in a small compass*. &c. London, 1737, 8vo. This tract was reprinted in a late edition of Grey's *Memoria Technica*, D G. Morhof *Polyhistor*, &c. edit. quart. Lubeck, 1747, 2 vols. 4to. Fr. B. J. Feyjoo, *Cartas eruditas y Curiosas;* Madrid, 1781, 5 vols. 4to. D. J. L. Kluber; *Compendium der Mnemonik;* Palm. 1804, 4to. Graffe, *Katechetisches Magazin;* Gottingen, 1801, 8vo. J C. von Aretin, *Denkschrift über den wahren Begriff und Nutzen der Mnemonik*, &c. Munich, 1804 8vo. Ejusd. *Systematische Anleitung zur Theorie und Praxis der Mnemonik*, &c Sultzbach, 1810, 8vo. C. A. L Kästner, *Mnemonik; oder System der Gedächtniss—Kunst der Alten*, &c. Leipsic, 1804, 8vo. Ejusd. *Leitfaden zu* *seinen Unterhaltungen uber die Mnemonik*, &c. Leipsic, 1805, 8vo. *The New Art of Memory, founded upon the Principles taught by M. Gregor von Feinaigle*, &c. London, 1812. Of this work a second edition, with additional illustrations, was published in 1813.

MOBILE, a river of the United States of North America, in the state of Alabama, is formed by the united streams of Tombigby and Alabama rivers. The extreme north-west sources of Tombigbee are in the state of Mississippi, near the south line of Tennessee, from whence the different branches flow south-east into Alabama, where, uniting, they form the Tombigbee, which flows nearly due south to its junction with the Alabama, at N. Lat. 31° 05′. The Tombigbee receives, besides many lesser confluents, the Tuscaloosa, or Black Warrior, a large stream from the north-east. The entire length of the Tombigbee is about 300 miles, by comparative course.

The Alabama is formed by the united streams of the Coosa and Tallapoosa, which both rise in Georgia, and flowing to the south west, unite at N. Lat. 32° 23′, and from thence to the junction with Tombigbee assumes the name of Alabama. The entire length of the Alabama, from the sources of the Coosa to the head of Mobile river, is, by comparative course, about four hundred miles. A considerable branch from the north, called the Cahaba, enters the Alabama about one hundred miles, by the windings of the stream, below the junction of the Coosa and Tallapoosa. Cahaba, the seat of government for the state of Alabama, is situated at the mouth of the Cahaba river.

The river Mobile is about forty miles in length, from the head of Mobile bay to the junction of the Tombigbee and Alabama rivers. Within a very short distance of its head, the Mobile divides into two branches, that of Mobile proper to the west, and Tensaw to the east. These never again reunite, but flow separately into Mobile bay, with several inlets from one to the other. The islands enclosed between the main branches and the inlets are, in general, liable to inundation.

The Mobile river admits vessels of twelve feet draught in all its length; the Tombigbee, those of five feet to Fort Stoddart; and Mobile, those of about six feet to Fort Claiborne.

MOBILE Bay, opens below the mouth of the Mobile and Tensaw rivers, and gradually widens from four to ten or twelve miles, and, extending thirty miles nearly south, again contracts to about five miles, having Dauphin Island in nearly the middle of its entrance into the gulf of Mexico. The main channel, between Dauphin Island and the Point of Mobile, has a depth of about 18 feet. The channel between the main shore and Dauphin Island, known by the name of the Pass au Heron, has only six feet. A bar of thirteen feet water crosses Mobile bay three miles below the town of that name.

MOBILE Point, is a long, low, sandy, and narrow peninsula, which bounds Mobile bay on the south, extending from the bay of Bon Secours, the south-eastern extremity of the former, towards Dauphin Island, towards which it approaches to within three miles. This point has been rendered remarkable, by the erection of a military post on its extreme west extension, called Fort Bowyer.

This fort was attacked, September 15th, 1814, by a British squadron, consisting of two vessels of 28 guns each, and one of 18 guns, with a land force of 200 Indians, and 110 marines. The British were repulsed, with the loss of the Hermes, and about one hundred men killed and wounded.

After their defeat at, and retreat from New Orleans, the British attacked and took Fort Bowyer, on the 15th of February, 1815.

MOBILE Town, is situated on the west or right shore of Mobile bay, near the mouth of Mobile river, upon a bank elevated eighteen or twenty feet above the surface of the water in the bay. Mobile contains about two hundred houses and one thousand inhabitants. It is a place of considerable trade, though the entrance to the harbour is inconvenient for vessels drawing more than eight feet water. A long, narrow, and low island lies before the town, and extends about five miles above, round which large vessels are obliged to pass in order to reach the harbour, in which any vessel can enter in safety which can pass the bar, three miles below the island.

Mobile is situated at N. Lat. 30° 44′, and W. Long. from Washington City, 10° 55′, and from Greenwich, 87° 55′. Darby.

MOCHA, or Mokha, a maritime town of Arabia Felix, on the eastern coast of the Red Sea, is situated in the midst of a barren plain, about 15 miles north from the Straits of Babelmandel, in 13° 16′ N. Latitude, and 43° 11′ 15″ E. Longitude. It is placed between two low points of land, which project from the shore, so as to form a bay capable of sheltering such ships as can approach within a mile of the shore. On each of these points, which are about five miles distant from each other, is constructed a circular castle, built of stone, and provided with artillery, (either of which a British ship of war would level with the ground by a single broadside;) and nearly in the centre of the walls of the town, fronting the sea, is a similar fort, protecting the only gate in this quarter for the entrance of goods and passengers. From this gate a pier of stone runs out in a due westerly direction for the space of 150 yards, which was built about the middle of last century, by Captain Watson, superintendant of the Bombay Marine. The town itself stands so close to the shore, that during a westerly wind the sea washes against the walls, and is about a mile and a half in length from north to south, and half a mile in breadth. It is completely surrounded with walls of hewn stone, about 16 feet high on the sea-side, but about 30 in some places on the land-side, which are generally kept in good repair, and provided with loop-holes for arrows or musketry at the distance of every five feet. There are also batteries at each end of the town, and round towers on the walls at equal distances. But the walls are too thin to withstand a cannon ball, and the batteries scarcely able to bear the firing of their own guns. The houses fronting the sea are very lofty, built of stone, and all white-washed. There are several mosques in the place, the minarets of which rise to a considerable height, and the largest of them serves as a landmark to ships entering the road, particularly as a steering point to avoid the dangerous shoal, which begins about four miles from the shore, and reaches nearly to the pier-head. There are several tombs or square edifices, covered with circular domes, which break the uniform line of the flat-roofed houses, and altogether the appearance of the town, when seen from the roadstead, is striking and handsome. But the expectations of the stranger are completely disappointed as soon as he enters the gates, when he sees the streets covered with filth, and full of vacant spaces, or the ruins of deserted habitations. The principal building in the town is the residence of the Dola, a large and lofty structure with turrets on the top, and a variety of fantastic ornaments in white stucco. One front of it looks towards the sea, and another into a square, the only regular place in the town where the Dola and his officers amuse themselves in throwing the jerid. The best houses look towards the sea, and are chiefly situated to the north of the sea-gate. They are mostly built of brick made by the heat of the sun, and, unless carefully preserved from the access of moisture, are soon reduced to a heap of mud. The windows are generally small, placed regularly in the walls, and seldom capable of being opened for the admission of fresh air. The floors as well as the roofs of the larger houses, are made of chunam, laid on pieces of plank or thin sticks, closely arranged like laths across the beams, but are extremely uneven, a circumstance which occasions less inconvenience where neither chairs nor tables are used. The internal structure of the habitations is uniformly bad, the passages long and narrow, and the stairs so steep as to be ascended with difficulty. The lower orders live in huts, composed of wicker work, covered on the inside with mats, and sometimes on the outside with a little clay, the roofs of which are uniformly thatched, and each of which has a small yard fenced in front. The suburbs are situated to the south of the town, with a large vacant space between them and the walls, and contain as many inhabitants as the city itself, but chiefly of the poorer classes. One quarter is occupied by Jews, another by prostitutes, a third by the public slaves, who are mostly Abyssinians, employed in repairing the buildings or loading the vessels belonging to the government, and the other districts, by labourers, artisans, and a few gardeners, who, by means of great industry and plenty of manure, contrive to raise a little sallad, pulse, and sweet potatoes. The amount of inhabitants, both within and without the walls, is not supposed to exceed 10,000.

The climate of Mocha is extremely sultry, in consequence of its vicinity to the arid sands of Africa, from which the south-east winds blow above eight months in the year, and often with such violence as to prevent all communications between the shore and the vessels in the road. During other three or four months, the opposite monsoon blows from the north-west with less violence, but with still greater heat. The country in the vicinity of Mocha is remarkably dreary, and, for a circuit of ten miles, consists of arid sand, covered by a saline efflorescence, and with scarcely any appearance of vegetation, except the common mimosa, and a species of salicornia; but near to the town are numbers of date-trees, of stunted growth, and a few patches of vegetables in the neighbourhood of the wells. The town, however, is well supplied with provisions from the inland districts and the opposite coast of Abyssinia, and in summer great abundance of excellent fruits are brought from the adjoining country from 20 to 50 miles distance. The water is brackish and unwholesome to strangers, but pure water is brought daily to market from Moosa, a town about 20 miles inland.

About the end of the 14th century Mocha was not in existence, but, about the end of the 16th, it had become the great mart for the trade between India and Egypt, and about 1738 it seems to have reached its greatest height of prosperity, when the English, French, and Dutch, carried on a regular trade with it, by the Cape of Good Hope, for the coffee which used formerly to go by Suez across Egypt to Alexandria. This article, which is the principal produce of the country, together with gum-arabic, myrrh, and frankincense, which are brought from the opposite coast of Africa, form the greater part of the export trade of Mocha, and of which the larger portion still goes up the Red Sea to Suez. The imports are very considerable, particularly from India and Muscat, the greater part of which traffic is carried on through Banian traders from Surat, who are found in great numbers at Mocha, and are indulged with the public exercise of their religion.

Mocha, as well as the other towns belonging to the Imam, is governed by a Dola, who is usually a slave, who can be removed at pleasure, and made to disgorge the profits of his government, which are very considerable, and arise from the sums levied upon the Banians and other foreign merchants. The second officer in the town is the Bas Kateb, or Secretary of State, who is always an Arab, and considered as a licensed spy over the Dola. The third is the Cadi or Judge, and these three compose the divan, where all public business is conducted, and where the Dola has only a vote along with the rest. The police is very strict during the night, and any person found out of his house after the Dola has retired to rest, which is indicated by the drums beating before his door, would be conducted to prison. The garrison generally consists of about 80 horsemen and 200 foot soldiers, armed with match-locks and crooked daggers. These troops have no appearance of discipline or of warlike habits, and, when on guard at the different gates, are seen reclining on couches, with their matchlocks lying neglected by their sides, and a cup of coffee or smoking-pipe in their hands. They attend the Dola every Friday on his procession to the great mosque, and are afterwards exercised in the front of his house: they are tolerably good marksmen, but require a long time to take aim.

The food of the lower ranks of Arabs consists of a coarse grain raised in the country, juwarry, ghee, dates, and fish, which last article is very abundant and excellent. The crabs, particularly, are uncommonly large and plentiful, some of them not less than four pounds in weight. The higher orders occasionally use also beef and mutton boiled to rags, with the addition of a little pillau. The cawa, made from the husk of the coffee-berry, is drunk by most of them several times a-day, and the pipe is rarely out of the hands of the men. They are not very strict in the ceremonies of their religion, except in the performance of their ablutions, and on the Friday, the Mahometan Sabbath, the lower orders carry on their usual occupations. Since the triumphs of the British arms in India, their conduct has become more tolerant towards Christians, who may now walk along the streets without being liable to insult, but who are still prohibited from going out at the Mecca-gate, though both Jews and Banians are indulged with that privilege. The character of the Arabs who inhabit the town is very inferior to those of the country, who still follow the pastoral habits. They are cowardly, cruel, revengeful, lewd, dishonest, inordinately addicted to falsehood in every form, and scarcely possessed of a single good quality. See Parson's *Travels;* Valentia's

Voyages and Travels, vol. ii.; Bruce's *Travels*, vol. ii. (*q.*)

MODENA, (*Mutina*,) a city of Italy, situated in North Latitude 44° 38′ 51″; and East Longitude, reckoned from the meridian of Ferro, 28° 34′ 59″.

This city is situated on the *Via Emilia*, in the pleasant plain of Lombardy, and is the capital of the duchy of Modena. It is also the seat of the sovereigns, and of the supreme tribunals. It is surrounded by a good wall, with a fortress in the side between the north and west, and is distinguished by spacious squares and streets, adorned with noble edifices, pleasant environs, and by the ample public promenade, which was formed and embellished by the present sovereign, Francis IV. The royal palace is one of the finest in Italy. The tower is of beautiful architecture, all coated over with white marble, one of the seven of that description in Italy. It is a singular property of the Modenese soil, that in digging into the earth, to the depth of about sixty feet, there arise veins of very pure spring-water; thus affording excellent perennial fountains. The population of this city amounts to about 26,000 souls.

Modena is a very ancient city, of which the first mention occurs in the year of Rome 535, during the war with Carthage: at which period the triumvirate commissioned to assign the lands to the new colonists shut themselves up in Modena, in order to escape the fury of the Baic Gauls; from which circumstance it may be inferred, that this city was, at that time, well fortified, and capable of enduring a siege; and, therefore, most probably founded a long time before. In the year 567 it was made a Roman colony; and, in the civil war which broke out in the year 675, between the two consuls Q. Catulus and M. Lepidus, Pompey here besieged M. Brutus, father of that Brutus who killed Cæsar. Still more celebrated was the siege sustained here by Brutus, in the year of Rome 709, against M. Anthony, and the defeat of the latter in the year 710, under the walls of the city, by the consuls Hirtius and Pansa, with Cæsar Octavianus, afterwards Augustus, in consequence of which Anthony was compelled to raise the siege. Seven months after this victory, Lepidus, Octavianus, and Anthony, divided the republic among them into three parts, having met for this purpose in a small island in the river Lavino, in the Modenese territory, according to the opinion of most writers. The revolutions to which Italy was exposed during the time of Constantine, and the invasions of the barbarians, were more or less common to the city of Modena, which, after having figured at the time of the peace of Constance among the Italian republics, and being in danger from the internal factions of the Guelfs and the Ghibbellines, threw itself into the arms of the Princes of Este, by electing for its sovereign, on the 15th December, 1288, Obizzo II. Marquis of Este. These princes governed the city until towards the commencement of the fourteenth century, when the desire for republican forms again revived in Italy. From this period there was an *interregnum* of about forty years, during which Modena was governed by various masters, and suffered much from hostile factions. Finally, in the year 1336, Obizzo III. of Este, resumed possession of the city, which his successors enjoyed till the year 1796, with the exception of some periods of interruption, occasioned by the wars which from time to time desolated the Italian peninsula. In the last mentioned year Modena was occupied by the French, and afterwards formed a part of the kingdom of Italy, until the year 1814, when it was restored to its legitimate sovereign, Francis IV. Archduke of Austria.

The government is monarchical. There is, however, a noble regency of conservators, who administer the public patrimony of the community, under the direction of a governor named by the sovereign. There is a bishop, a chapter, and a seminary; and also a flourishing college for the education of native and foreign nobles. The university has been restored by the reigning sovereign, who allows the students the use of his vast and elegant library, which is preserved in his royal palace, and is rich in books and precious manuscripts. He has also revived the Academy of Sciences, literature, and the arts, the Academy called Atestina, or the fine arts, and has here fixed the seat of the Italian Society of Sciences, formerly instituted by the illustrious Chevalier Gio. Mario Lorgna Veronese. The Capitular archive of the cathedral is celebrated on account of the antiquity of its documents, and its very honourable, royal, and imperial diplomas, among which are some originals of Charlemagne. Still more rich is the secret archive of the family of Este, in which are preserved a great many precious parchments and remarkable documents relative to the antiquity and grandeur of that family, one of the most ancient and noble lines of sovereign princes. There are various charitable institutions in Modena, among which are the grand hospital, the house of recovery, and the house called St. Paul, which was recently founded by the present sovereign for the education of poor girls.

Many learned men have flourished in the dominions of the house of Este, as may be seen in the work, entitled *Biblioteca Modenese*, by C. Tiraboschi; and among whom are distinguished the names of Sigonio, Castelvetro, Montecuccoli, Vallisniere, and Muratori. The means which this city possesses at present for the cultivation of science, literature, and the arts, have brought letters into high estimation, and rendered flourishing the study of the sciences.

The country, in general, is fertile in all kinds of grain, leguminous vegetables, and mulberries; and in all sorts of large and small cattle, grapes, chesnuts, and fruits. The principal commerce of this state consists in wines, spirits, silks, bestial and coarse cloths. Few manufactured articles are exported; because, being an agricultural country, the greater part of its population is employed in cultivating the ground. It has, however, one very lucrative branch of commerce, viz. that of hats, called *cappelli di truicolo*, of which great numbers are exported.

MOFFAT, the name of a town and parish of Scotland, in the county of Dumfries. The town is situated on the east side of the river Annan, at the head of a plain or valley extending upwards of 20 miles along the banks of the river.

The principal street, through which passes the great road from Edinburgh to Dumfries and Carlisle, is spacious. The town contains many good houses, two inns, excellent lodging-houses, with a handsome church, and an assembly-room.

Moffat is principally celebrated for its mineral waters. The sulphureous spring called Moffat Well is situated about a mile and a half from the town. There is a good carriage road to the well, and excellent accommodation for the company while they are drinking the water. This well was discovered about 170 years ago; and, according to Dr. Garnet, it contains muriate of soda, 36 grains, sulphuretted hydrogen gas, 10 cubic inches, azotic gas, 4 cubic inches, and carbonic acid gas, 5 cubic inches.

The chalybeate spring called Hartfell Spa, issues from a rock of alum slate, on a tremendous ravine on the side of Hartfell. According to Dr. Garnet, a wine-gallon of it contains sulphate of iron, 84 grains, sulphate of alumine, 12 grains, azotic gas, 5 cubic inches, together with 15 grains of oxide of iron, with which the sulphuric acid seems to be supersaturated, and which it gradually deposits on exposure to the air, and almost immediately when boiled. The other chalybeate spring near the bridge is now choaked up. There are vestiges of a Roman military road, and of several stations near the town. About a mile east of the Roman road are two large caves cut out of freestone rock.

In 1811, the parish contained 406 families, of whom 120 were employed in trade, and 72 in agriculture; and the total population was 1824 inhabitants. See Dr. Singer's *Agricult. Account of Dumfries-shire*, p. 48, &c.

MOGADORE, or Mogodor, a maritime town of the empire of Morocco, is situated in 29° 50′ of north latitude, and 9° 36′ of west longitude, about 48 miles south of the river Tensift. It was founded in the year 1760 by the Emperor Mohammed-ben-Abdallah-ben-Ismael, and received its name from a sanctuary in the vicinity called Seedi Mogodol. But by the Moors it is called Suerah, or more properly Saweera, a name conferred upon it by the Emperor in allusion to the beauty of its appearance, and particularly the regularity of its construction. It is built upon a low, flat, sandy tract, and in spring tides is almost surrounded by the sea, but is defended from the encroachment of the ocean by a line of rocks, which extend from the northern to the southern gate. The harbour, or bay, is formed by a curve in the land, and a small island, about a quarter of a mile from the shore, but is rather shallow, and daily becoming more so, by the accumulation of the sand, so that ships of war, or of great burden, must lie at anchor above a mile and a half west of the Long Battery on the west of the town towards the sea. At the entrance of the road is a circular battery, and, within the harbour, at the landing place, are two long batteries mounted with handsome brass eighteen-pounders. On the land-side also, to the eastward of the town, is a battery of considerable force, fully sufficient to keep the Arabs at a distance; and were the other forts well mounted and manned, it is supposed that six or seven large frigates would be required to reduce the place. There is a very spacious cistern under the battery at the Water-port gate, which is filled with rain-water from the adjoining terraces, which is never used except in cases of emergency; and as the water for the use of the town is brought from the river, this supply might be rendered inaccessible in the event of an attack. There are two towns, or rather a citadel and an outer town, both of which are walled in and protected by cannon. The citadel contains the custom-house, the treasury, the residence of the alkaid, the houses of the foreign merchants, and those of some of the civil officers; and as the houses are all of stone, and of a white colour, the appearance of the town at a distance is extremely beautiful; but the streets (which cross each other at right angles) are very narrow, and the houses have few windows towards them, so that the interior of the place has a sombre look. The houses of the foreign merchants are very spacious, having eight or twelve rooms on a floor, all opening into a gallery, which goes round the whole inside, forming an area in the centre which is appropriated to the transacting of business and the warehousing of goods. The roofs are flat, and beat down with a composition of lime and small stones, which forms a very durable covering, and serves as a walk for the family.

The emperor who founded the town was very desirous to render it a flourishing commercial port. To impress his wishes on the minds of the inhabitants, he commanded his principal officers to bring mortar and stones, and with his own hands he began to build a wall, which is still to be seen on the rocks to the westward of the town. In order also to encourage the merchants to erect substantial houses, he not only presented them with ground, but allowed them to ship produce free of duty, as a remuneration for their expenses.

The Arabs, however, have so great a repugnance to quit their tents, and such a contempt for the restraints of a town residence, that he was obliged to draft a certain number of persons from the Arab or Bezebber tribes, as well as from some of the towns, and to compel them to settle in his new city. The population now amounts to about 10,000, and it is the only part of West Barbary which maintains a regular commercial intercourse with Europe. It differs from every other port along that coast in this respect, that the inhabitants have no other resource or occupation than commerce, and by it every individual is directly or indirectly supported. The town is in a manner insulated by sand-hills, which separate it from the cultivated country, and which are so continually drifting by the incessant high winds of summer, that scarcely any kind of esculent plants can be raised for the supply of the inhabitants. The fruits and vegetables are therefore brought from gardens between four and twelve miles distant; and the cattle and poultry from the other side of the sand-hills. The foreign merchants of Mogadore supply the various cities and markets of the empire with European goods, receiving in return the produce of the country for exportation; and formerly used to give to the natives credit to a considerable extent. But of late years the Moorish government has greatly abridged their power of enforcing payment, so that credit is almost annihilated, and transformed into barter, which has curtailed the trade, and confined it among fewer hands. The principal imports are Yorkshire and West country cloths of various colours, superfine cloths, druggets, linens, cambrics, muslins, Indian blue linens, striped India silk, velvets, damask, and raw silk, alum, copperas, sugar, iron, hardware, gums, spices, tea, pewter, tin bars and plates, white and red lead, copper in sheets, thread, mirrors, earthenware, glass, brass pans and copper teakettles, Dutch knives, paper, cotton, coral and amber beads, wire, cochineal, iron nails, deals, dollars; which, with several other articles, amounted in 1804 to the value of 151,450*l*. The principal exports are almonds, walnuts, gums, wax, hides, olive oil, wool, ostrich-feathers, elephant's teeth, dates, raisins, anise-seeds, tallow, &c. which amounted in the same year, after paying freight and duties, to 127,679*l*. The police of the town is very strict, and there is neither house-breaking nor rioting in the place. The governor of the city frequently goes the rounds in person, and looks the watchmen in the face, who lie on their sides with their ear to the ground, that they may the better hear any noise, and who would be in danger of capital punishment, if found asleep on their post. See *Jackson's Account of Morocco;* Chenier's *Present*

State of the Empire of Morocco; and Paddock's *Narrative of the Shipwreck of the Oswego.* (*q.*)

MOGUL EMPIRE. See India.

MOHAWK, a river of the United States, in the state of New-York, is the north-west branch of the Hudson. The Mohawk rises in Lewis county, by a number of branches, which unite, and flow south to Rome, in Oneida county. Here this river turns to a little south of east, which course it pursues to its junction with the Hudson at Waterford and Lansingburgh. The Mohawk is impeded by two falls; these are, the Little Falls, in Herkimer, and those of Cohoes, between Saratoga and Albany, two miles above Waterford.

The entire length of the Mohawk, by comparative courses, is about 130 miles; it is navigable at high water below Rome. This stream receives from the north only two creeks of any consequence, East and West Canada, and from the south Schoharie river, from which the county of Schoharie takes its name.

Darby.

MOISTURE. See Hygrometry and Meteorology.

MOLD, a town of Wales in Huntingdonshire, is agreeably situated on the river Alum. It consists of four streets, which are neat and wide. The houses are in general well built. The principal public buildings are the church, the town-hall, in which the assizes are held, and a large hospital. Great quantities of coarse woollen cloth were formerly manufactured here; but the inhabitants are now employed principally in the manufacture of copper and brass articles, and the knitting of stockings. The remains of its ancient castle, and some ruins, supposed to be Roman, are the only antiquities of the place. The town contains 700 houses, and 4235 inhabitants. See the *Beauties of England and Wales*, vol. xvii. p. 689, and Wynne's *History of Wales.*

MOLDAVIA, a country of Europe, bounded on the north and north-east by Poland and the river Dneister; on the south by Bessarabia and the Danube; and on the west by Wallachia, Transylvania, and branches detached from the Carpathian mountains. Its extreme length is computed at 280 miles, and its breadth at 200. The surface is finely diversified with hills and valleys, with extensive forests and numerous streams, of which the principal are the Pruth, Sireth, Moldau, Danube, and Dneister; and it contains several small lakes. But the summer heats convert several of the latter to marshes, exhaling dangerous miasmata. The climate is rigorous in winter, and oppressive in summer. During six weeks the Danube is frozen; when the ice is capable of bearing the heaviest artillery, and the intercourse on land is by means of sledges on the snow. Much rain falls in summer, accompanied by thunder storms every evening about the same hour, and slight earthquakes are frequent.

Moldavia abounds in minerals. Particles of gold are rolled down by some of the rivers. Fossil salt is plentiful; a quantity of nitre is exported; and the prince of this territory must send 25 tons of nitre yearly to Constantinople.

The Turkish navy is supplied with the finest oak from the forests of Moldavia, and also with masts and cordage of native growth. Wheat, barley, oats, millet, and maize, are in ordinary cultivation; the usual return is sixteen fold, and in favourable seasons twenty-five. Vines are planted in sheltered situations on the declivities of hills, but the grapes are not allowed to come to perfection, whence the wine obtained from them is inferior, though a great quantity is exported.

Great numbers of bees are reared by the Moldavians. The hives are lodged in portions of the hollowed trunk of a tree, about three feet long, and closed at the upper end. Those converted to use are smoked towards the end of October, and those meant to be preserved are kept in cellars covered with straw during winter. Bees are an article of taxation: The produce of the tax, in 1785, amounted to 4000*l.*

The principal domestic animals are horses, cattle, sheep, and goats; and great herds of swine are fed in the forests; the wild animals are wolves, foxes, bears, martins, hares, and others. About 10,000 martins are taken yearly, and about 500,000 hares, in this country and Wallachia, which are chiefly hunted during winter. It was lately computed that the principality contains 3,248,000 sheep and goats; a large proportion of which are carried to Constantinople; for the Turkish government sends a company hither every spring to purchase domestic animals and provisions, in an oppressive manner, at a low and arbitrary price. The horses are esteemed for their spirit and docility, and are bought for the use of the Austrian and Prussian cavalry. Some of the wealthy proprietors have 400 or 500; and it is said they allow them to remain always unsheltered in every season. Beyond the river Pruth there is a particular breed, superior to the rest.

The government is nearly absolute, in the person of a prince, waivode or hospodar, appointed by the Turkish emperor, and selected from the Greek families at Constantinople. He purchases his appointment, and its duration is dependent on the Turkish government. A divan, or supreme council, consisting of twelve members, assembles at least twice weekly to decide on judicial and other matters; but its authority is rather nominal than real, almost every thing being conducted at the pleasure of the prince. The laws of the province have been lately revised and published, by command of the present prince of Moldavia, who was appointed in the year 1812. Capital punishment is very rarely inflicted; but the prince has absolute power of life and death throughout his government.

The prince of Moldavia is responsible to the Porte for a yearly tribute of a million of piastres, or 33,333*l.* sterling; and the total revenue of the country is said to amount to 46,666*l.* The sources of revenue are a capitation-tax from the peasantry, and small landholders, salt mines, customs; a tax on tobacco, wine, bees, and the pasturage of sheep and cattle.

The chief trade of Moldavia consists in the export of timber, grain, yellow berries, live stock, wool, wine, wax, and honey; and in the import of coffee, sugar, pepper, rum, fruit, foreign wines, furs, cotton and woollen cloths, glass and earthen ware. Timber for ship-building and staves is floated down the smaller rivers into the Danube; wheat is contraband, but Turkish vessels come to carry away about 1,500,000 bushels from this and the neighbouring principality, by the authority of government. Wax is carried to Venice, and honey to Constantinople: and the other articles, most of them loaded with improvident restrictions, are exported elsewhere. About 1120 tons of coffee, and 1260 of sugar, are imported at Galatz yearly; and manufactures of different kinds from Germany, which are offered as English, meet a ready sale. The fur and leather trade is mostly conducted by Russians, the silk and woollen by Greeks, the morocco-leather, spiceries, and aromatics, by Turks, and jewellery by Jews.

The total population of Moldavia was computed in 1794 at 420 500 souls, of whom 20.000 were supposed to be ecclesiastics. At present the population is calculated at 500,000. The greater part is dispersed in the country, inhabiting miserable villages, where the huts are fashioned of wood, daubed with clay, having doors that scarcely close, paper windows, and the roof open to the winds. In winter their tenants descend to subterraneous cells, which are easily heated, where both sexes and all ages mingle promiscuously together, sleeping on a coarse rug, which serves them equally for bed and coverlet. They subsist for the most part on a kind of thick porridge or dough, called mamalinga, made of the flour of Indian corn. During a famine in 1795, they were compelled to live on acorns and the bark of the elm, ground and mixed with meal; yet many, deprived of even this wretched fare, died of want.

There are few towns of considerable size or importance. The capital, Jassy or Yassi, is situated on the lake and river Baklui, running into the Pruth, and occupies a vast extent of ground, from the houses being detached, and surrounded by yards and gardens. The cathedral, churches, and convents, the palaces of the boyars, or nobles, and that of the prince, form the most conspicuous features. The last is very spacious, fitted up partly in the European style, and is capable of accommodating 1000 persons. In general the houses consist of only one storey, built of brick, and whitewashed both without and within, and are roofed with wood; but there are many of a different construction, and after the best style of European architecture. Yassi contains seventy churches, public hospitals and schools for about 200 pupils, who are instructed in the national language, ancient and modern Greek, writing, and arithmetic. Education nevertheless is very much neglected throughout the principality. Many coachmakers are established here, from the custom among the better classes of never going out on foot. The streets, instead of being causewayed, are floored with thick beams of the finest oak, which must be renewed every five or six years. In rainy seasons they are covered with deep liquid mud, and in dry weather with thick black dust, which, added to the stagnation and accumulation of putrescent substances below, are productive of numerous diseases. Hence Yassi is esteemed an unhealthy residence, and the inhabitants are constantly afflicted with intermittent, bilious, and putrid fevers. Its population is computed at 40,000. Galatz, the sea port and chief emporium of the province, is situated on the Danube, 65 miles from Yassi, where that river is navigable by vessels of 300 tons burden. Here there are public granaries for wheat, and many large warehouses belonging to private merchants. A number of vessels frequent the harbour, among which are some from the Ionian islands, of late under British colours. The stationary population of this town amounts to 7000, but there is a great resort of strangers engaged in commercial pursuits.

Moldavia is part of the ancient Dacia, whose inhabitants resisted the progress of the Roman arms. The King of the Visigoths, being compelled to retreat hither in the fourth century, erected a wall between the Pruth and the Danube, where various antiquities of a remote era, as described by Count Marsili and other authors, are still to be recognised. In the thirteenth century it was occupied by a new tribe, under their leader Bogdan, who assumed the Sclavonic title, wayvod or voivode, equivalent to reigning prince, and from him the country received the name, Bogdiana. It became tributary to Turkey in 1536, and since, having been the theatre of sanguinary wars between that empire, Russia, and Austria, each has alternately held the sovereignty. At length the growing power of Russia obtained the cession of the best portion of the province, between the Pruth and Dneister, in the year 1812, which may perhaps be anticipated the precursor of the rest, on the commencement of the first hostilities between the empires.

MOLIERE, (Jean Baptiste Poquelin,) the most celebrated author of French comedy, was born at Paris in 1620. His father and granfather were valet-de-chambre upholsterers to the royal household of France. Young Poquelin remained in his father's house till the age of fourteen, receiving no other education than was conformable to the employment which it was intended that he should follow; but having acquired a taste for reading, he was, by his own earnest desire, and at the instance of his grandfather, sent as a day-scholar to the Jesuits' College of Clermont. He there formed an intimacy with Chapelle, Bernier, and some other men of promising talents, and through their friendship was permitted, in their company, to attend the lectures of the celebrated Gassendi. The journey which Louis XIII. made to Narbonne, in 1641, gave a temporary interruption to the course of his studies; for his father having become infirm, and unable to follow the court, young Poquelin was obliged to go in his place, and to attend to the duties of his father's office; but on the death of his father, he returned to Paris, and had it in his power once more to pursue the bent of his genius. It luckily took a turn for the theatre. The taste for theatrical entertainments was, at this time, at a great height in France. Cardinal Richlieu himself was attached to them, and protected dramatic authors.— Among the new companies of comedians which began to be formed at Paris, our author entered into one of them, which was called L'Illustre Theatre. It was at first only a private society, established for the sake of amusement; but by degrees it made its exhibitions public, and fixed itself in the suburbs of St. Germain's. Either from regard to the feelings of his relations, who disapproved of his following this vocation, or after the example of his comrades on the stage, our author dropt his proper family name of Poquelin, and assumed that of Moliere, by which he was destined to be known to posterity. He soon after associated himself with a provincial actress, called La Bezart, and they formed a company, which set out for Lyons. At that city, in 1653, his comedy "*L'Etourdi*" was for the first time represented. Being an early essay, this piece (as we might expect) is not to be ranked among the masterpieces of Moliere. It has more intrigue than interesting delineation of character; and the events do not spring out of each other with that felicity and force of natural succession, which he afterwards so well knew how to infuse into his comic plots; but it has great vivacity of dialogue, and contains one character, the intriguing valet Mascarille, which is highly amusing. If we consider, too, the state of French comedy previous to Moliere, which was nothing better than a compounded imitation of the extravagance of the Spanish, and the buffoonery of the Italian drama, the appearance of the "*Etourdi*" must be regarded as an era in the national literature. This comedy went off at Lyons with great eclat, and Moliere proceeded from thence to Languedoc, in order to offer his services to the Prince of Conti, who at this time presided over the states that were assembled at Beziers. Here Armand de Bourbon, who had known our author at Paris, and had often been amused with his acting in the "Illustre Theatre," received him with great kindness. The "*Etourdi*" was reacted at Beziers with the same success as at Lyons, and was quickly followed by "Le Depit Amoureux," and "Les Precieuses Ridicules." The former of those pieces displays Moliere as a poet, still relying mainly for comic effect on the intrigue and surprise of incident which prevail in the Spanish school; though there is a more artful arrangement of incidents than in the "*Etourdi*," and great pleasantry and ingenuity displayed in the labyrinth of perplexed situations in which the characters are involved, and from which the denouement dismisses them. The latter piece, the "*Precieuses Ridicules*," is of a higher order of comedy. The author shines here, for the first time, as a deep and delicate painter of manners and characters. It is an exquisite satire on the affectation of high-flown sentiments and witty language, which are said to have then prevailed in France. The piece was acted incessantly for four months, and the confluence of spectators enabled the managers to charge double price for admission to see it. Among the compliments paid to it, one is mentioned to have been uttered by an old man, who cried out from the gallery, "*Courage, Moliere! voila une vraie comedie!*" His reputation was now widely established; and he had a right to congratulate himself on the profession which he had chosen. But all his success and celebrity could not overcome the repugnance of his relations to seeing him on the stage, and he was repeatedly besought by them to forsake it. Believing that the master of a boarding-school, with whom he had once lived, might have some influence with him, they sent the grave man to try to persuade him to give up the life of a player; but the result of the embassy was worthy of the history of a comic actor and comic author. Instead of being converted by his friend the schoolmaster, he persuaded the elderly gentleman to become himself a player, and launched him on the boards in the character of a comic doctor, which he thought suited his appearance.* He next visited Grenoble and Rouen, and from the latter place returned to Paris, under the protection of Gaston Duke of Orleans, who introduced him to Louis XIV. and the Queen. He obtained permission to open a theatre in the metropolis; and the Guard in the old Louvre was first allotted him for that purpose. In 1664. it was changed for that in the Palais Royal, and, in 1665, he was placed in the service of the King, with a pension. He continually fed his reputation with new works, and produced many farces and slight pieces, besides his regular comedies. In 15 years he supplied the theatre with thirty productions. Though his fame, however, was on the whole progressive, he was neither exempted from invidious nor just criticism; nor were all his pieces equally well received. From his comedy "*Le Cocu Imaginaire*," it was supposed that his style improved after his establishment in Paris; but his "*Don Garcia de Navarre*" acquired no reputation, and he yielded to the public opinion by forbearing to print it. In his subsequent piece, "L'Ecole des Maris," he however indemnified himself for this temporary failure. Among the principal objects of his satire, were the coxcomb men of quality of his time, called the petits-maitres, the pedants, and the affected belles esprits, male and female, and the medical faculty. His L'Amour Medecin was the first piece in which he embarked in a war with the last of these tribes, which continued all his life; for the "*Malade Imaginaire*," in which he still holds up the faculty to ridicule, was the concluding work of his life. The influence of common sense on modern manners has, no doubt, stript every description of professional men of any peculiarities which formerly belonged to them, so that Moliere's picture of doctors in the 17th century is likely to appear to us more exaggerated and illiberal than it really was with regard to the originals: nor is it assuming too much to suppose, that the very ridicule of Moliere contributed to diminish those traits of charlatanism and pedantry, which it would be, at this day, the lowest resource of caricature and farce to ascribe to the medical character. His comedy of the "Misantrope" is placed by his admirers in French criticism very high in the scale of his works, perhaps it is generally regarded as inferior only to Tartuffe. It is sadly defective, however, in interesting action, and has a great deal of prosing discussion in the dialogue, meant to pourtray characters by the repeated expression of their opinions and principles. In this respect he sometimes reminds us of our own Ben Jonson, and his imitators Cartwright and Randolph, in their less happy moments, when they substitute hard and abstracted ideas of human character for its natural development, and for the amusing business of comedy. The "*Misantrope*" was, accordingly, too spiritual in its touches for the Parisian audiences, and it was not so kindly received as his pieces of broader humour. In recompense, it has since received the suffrages of the more philosophical class of French critics, and it has unquestionably some fine traits of character-painting, amidst the superabundance of its opinionative discussion. One philosopher, J. J. Rousseau, has, with his accustomed singularity, objected to it on the grounds of its moral tendency. "It is a piece (he says) which holds virtue up to ridicule. This paradox was worthy of the writer who would have sent back human nature to barbarism as to a golden age. The misanthrope Alceste, Moliere's hero, he observes, is a man of rectitude, sincerity, and genuine worth; and yet he is made to appear ridiculous." All this is sophistry. Alceste, it is true, is represented as an honest man, whose "*failings lean to virtue's side;*" but still, with all his worth, he has failings, and they are legitimate objects of ridicule. The misanthrope's love of truth and plain dealing is carried, as Rousseau's sometimes were, to spleen and rudeness; as, for instance, when he has the cruelty to tell a poor vain poet to his face, that his

* We quote this anecdote from *Les Annales Dramatiques*, published at Paris in 1810.

verses are execrable. His positiveness in maintaining this point is made entertainingly extravagant, when, on being told that he is to be taken before a court of the marshals of France, he offers to prove that any man deserves to be hanged for making such verses. Here the virtue of sincerity is not, as Rosseau alleges, held up to derision; but the misdirection of the virtue. We are not made to laugh at the misanthrope's love of truth—but at his putting himself into a passion about a trifle, which neither called for his sincerity, nor justified his ill temper. The scene is therefore neither immoral nor irrational. But still Rousseau will insist that Moliere has degraded the picture of a good man, at the expense of consistency of character. He ought, he says, to have made him furious only against public vices, and not against the personal traits of wickedness of which he is the victim. The plain answer to this is, that it is most natural for a man to feel indignant at the vices which immediately affect his own happiness. Moliere certainly might have made his hero a *public-spirited misanthrope;* but unfortunately there are so few men-haters of this description, who are believed to be sincerely abstracted from all considerations of their own interest, that a misanthrope insensible to personal injuries would not have been, probably, received as a very natural character. He might have made him, if he had liked, a perfect and a wise being; but where would have been then the scope for comedy? Where would have been the failings to instruct us? And if he meant to paint a misanthrope, with what consistency could he exhibit a wise and perfect being? Such a man, if he existed, would not hate his species, but regard their errors with the very soul of compassion.

His "*Tartuffe*" is esteemed by his countrymen as the masterpiece of his works, and of their national drama. We must own that, to our taste, some others of his comedies, such as "*Le Bourgeois Gentilhomme*," "L'Ecole des Femme," &c. and "Le Malade Imaginaire," which bring "*laughter shaking both her sides*," seem to possess a more veritable tone of humour than the exhibition of so dark a villain as Tartuffe. We are not deterred from avowing this preference by the common remark, that the first and last of these pieces, in particular, incline to broad farce, and give us rather caricatures of transient follies in the manners of society, than draughts of permanent resemblance to human nature. But though the ludicrous images in these comedies may be bold and broad, we are not aware that they are unnatural; on the contrary, though they are heightened sketches of follies, which never meet us so glaringly in real society, we believe they seize the veritable, essential, and permanent traits of the ridiculous in human character. The absurdities and frailties of the species may be thus shewn, like playful or pernicious insects through a magnifying glass, but their stings and gambols and propensities are, by that means, only shewn to us more distinctly. With respect to the Tartuffe, the fault of its conclusion, by a resource supposed illegitimate in the drama, has been a thousand times noticed, namely, the order from supreme authority, which arrests the villain when he is at the height of his triumph, and conducts him to a terrible punishment. The gravity of the scene, we confess, seems to us a greater departure from comic effect than the means employed for the denouement; and in what we have said of the Tartuffe, we only mean that it is less exhilarating than the other comedies which have been mentioned. As an effort of skill and ingenuity, it is wonderful, for the art with which he throws a risible interest over the exhibition of such dark traits of atrocity as those of Tartuffe, and with which he amuses us by the success of a knave, all the time we are impatient for his detection. The subject was difficult, but Moliere had to encounter other difficulties than those of his subject. His exposure of the vice of hypocrisy in Tartuffe alarmed not only hypocrites, but some of the weak and well meaning devout. Whether we are to reckon Louis XIV., and his immediate advisers on this point, among the real or pretended devotees, it is certain that his Majesty, for some time, laid his veto on the representation of the comedy. The three first acts of Tartuffe had been represented, after the fetes of Versailles, in 1664, in presence of the King and the Queen-mother and consort. Louis declared, that, for his own part, he had nothing to say against the comedy; but he forbade its being represented in public, till it should be examined by persons capable of estimating its moral tendency. The bigots availed themselves of this circumstance to raise a clamour against the piece; though, for the most part, they were little acquainted with its contents. A pious curate, in a book which he presented to the king, decided that the author deserved to be burnt alive, and upon his own private authority awarded that punishment to Moliere. Some of the higher clergy, however, having had the moderation to hear the comedy read, were pleased to judge of it more charitably. A verbal permission for its representation was obtained from the king. The poet softened some expressions, which had appeared offensive; he gave it the title of "L'Imposteur," and disguised the person of his hypocrite under the appearance of a man of fashion, giving him a small hat, bushy locks, a sword, and a laced suit of clothes. In this state Tartuffe was risked on the stage in 1667, and was received with applauses; but next day an order was sent to suspend its representation; and though, at Moliere's instance, two gentlemen, "La Thorilliere," and "La Grange," repaired to the camp before Lille, where the King then was, and presented a memorial in favour of the piece, it was not till two years later that his Majesty gave an authentic permission for its being again brought on the stage. When it became fully known, the hypocrites were confounded, and the poet was justified, with regard to the dangers to the cause of morality which were supposed to be apprehended from the play of Tartuffe. We omit to give the particular dates or names of his numerous pieces. "La Malade Imaginaire" was the last of his compositions. The day on which it was to be represented for the third time, he felt himself more indisposed than usual with a complaint in his chest, to which he had been subject for a long time, and which had brought on an almost incessant cough. He makes an allusion to this infirmity, which must have often interfered with his acting, when Frosine says in "the Avare" to Harpagon, a part which Moliere played, "Cela n'est rien, votre fluxion ne vous sied point mal, et vous avez grace a toupir." (L'Avare, act 2, scene 6) His wife and friends intreated him to defer the representation of "Le Malade Imaginaire" till his health should be somewhat reinstated; but he answered, "What then must become of so many poor people, who depend upon its representation for their bread? I should reproach myself for having neglected a single day to have supplied them with necessaries." He accordingly exerted himself on the stage with unusual spirit, in performing this comedy; but in the third act he was seized with a convulsion fit, which he vainly attempted to disguise to the spectators by a forced laugh. He was carried home to his house in the Rue de Richelieu, where his cough augmented exceedingly, and brought on a vomiting of blood, that ended in suffocation. He expired on the 17th February, 1673, aged 53—supported by two women of the religious sisterhood, who used to come to Paris in time of Lent, for the purposes of charity. Harlai, the Archbishop of Paris, a man of dissolute morals, but desirous of pleasing the rigorists of the Roman church, refused him Christian burial; but the King interposed, and the prelate, after pretending to investigate the character of Moliere, and to be satisfied with the accounts which he received of his religion and probity, allowed that he should be interred privately in a chapel of the parish of St. Eustache. Another story is told, of the King having sent for the curate of the same parish, who, like his superior, had scruples about the right of a player to be buried in consecrated earth. "To what depth is your ground consecrated?" the King is said to have inquired. "To the depth of four feet," answered the clergyman. "Well then," replied Louis, "let Moliere be buried six feet deep;" and he added, as he turned his back upon the curé, "let me hear no more about this business." The bigotry of the populace impeded even the obscure funeral honours which were allowed to be paid to him, for they collected in great crowds before the door of his house on the day on which his corpse was brought out. Such was the return which his country made to the man whom Racine himself pronounced to be the greatest of his age. His wife, on hearing the refusal of the clergy to allow him Christian burial, is said to have exclaimed with tears in her eyes, "*France grudges a tomb to him to whom Greece would have erected altars!*" The saying was just and pathetic. It is only to be regretted, that the wife who spoke it was not, if we may trust the general report, worthy of Moliere. He is said to have been himself the victim of the most grievous of matrimonial distresses, which he paints so facetiously in comedy. The populace, whom his widow bribed to respect his remains, followed him decently to his grave; where he was quietly deposited by the light of an hundred flambeaus, which his friends carried to the ceremony. His widow afterwards married a comedian of the name of Guerin. She was the daughter of Madame Bezart, with whom he made his first theatrical excursion to Lyons, and with whom, it seems to be confessed by his biographers, that he had had a connexion before he was married to the daughter. The exasperated envy of some of his literary opponents accused him of espousing his own daughter in this Mademoiselle Bezart; but the calumny is sufficiently refuted by distinct evidence, that she was born before Moliere became acquainted with her mother. Moliere was in his person above the middle size, of a noble carriage, handsome limbs, and an exceedingly expressive countenance. His walk was slow—his air serious.—He had a high nose, a large mouth, a dark complexion, and very black, thick, and flexible eye-brows, which made his physiognomy very striking in comedy. He was not, probably, a first rate performer, owing to the weakness of his voice; but from the prominent parts which he took in his own comedies, he must have been a considerable one, and by no means incapable of doing justice to the characters which his imagination so strongly conceived. We are told by the French actress, who gives this minute description of his appearance, that he was fond of talking (*il aimoit fort a haranguer*) and that, when he read his pieces to his fellow-actors, he always wished them to bring their children, in order that he might draw hints from their natural movements. The same person adds, that he was mild, courteous, and kind in his general intercourse. He was not envious: to be sure he had little occasion to be so. When the "*Plaideurs*," a comedy by Racine, with whom he was at that time on bad terms, had lost possession of the stage, he was the first to assert its merit, and to bring it back to popularity. In company that pleased him, his conversation was very pleasant; but, as the contrary oftener happened, he was apt to be absent and melancholic in society, and consoled himself with secretly remarking the traits and manners of those about him, in order to store them up as hints for comedy. Many anecdotes of his benevolence are recorded. His friend Baron one day mentioned to him the case of a man whom extreme poverty prevented from waiting on him. His name was Mondorge.—"I know him," said Moliere. "He was a comrade of mine in Languedoc, and an honest man. How much do you think I should give him?" "Four pistoles," said Baron, after some hesitation. "Here, then," replied Moliere, "are four pistoles for me, and here are twenty more, which you shall give him from yourself." Mondorge was introduced to him: Moliere received him with open arms, and gave him also a magnificent dress, which enabled him to perform a tragedy. A beggar once asked our poet for charity, and he gave him a piece of gold. The mendicant brought it back, saying he supposed it was a mistake. "In what a hole has virtue hid herself!" exclaimed Moliere, and gave another gold piece to the poor man, telling him there was no mistake. His death, as we have seen, was occasioned by an impulse of benevolence. A high niche in the temple of modern genius is confessedly to be assigned to this writer, but whether he is to be ranked among the few first rate comic poets who bear the palm in universal literature, ancient and modern, is a question still agitated between the schools of French and German criticism. Voltaire has named him the father of true comedy; and as far as the French stage is concerned, nobody will dispute the assertion. According to La Harpe, he is the first of philosophical moralists; comedy and Moliere are synonymous terms, and his pieces are schools of instruction for the world. Chamfort calls him the most amiable teacher of human nature since Socrates, and affirms that Julius Cæsar, who called Terence a half Menander, would have denominated Menander a half Moliere. Unhappily Julius Cæsar's opinion about Moliere is not to be collected with precision, and we know too little of Menander to institute a fair comparison. But it is easier to compare Moliere with the poets of antiquity whose subjects he has adopted; and, whatever may be the result of the comparison, it is a respectable trait in his literary character, that he had sufficient knowledge and taste to apply to classical sources for enriching his drama. He brought, indeed, to the vocation of a dramatic writer, the most eminently useful and creditable advantages. Though born in middling life, he had opportunities of studying the manners of the court. He had studied Spanish and Italian comedy, and he was able to draw from Plautus and Terence the attic salt and true tone of comic character. He possessed an inexhaustible fund of gaiety, congenial with the best models from which he drew his resources; and even those who ascribed to him scarcely more than the merit of farce and caricature in comedy, acknowledge that he designs amusing caricatures with the firmest and happiest traits. They acknowledge, for instance, that even in farcical creation, the vain-glorious soldier of Plautus is less ably pourtrayed than the Bourgeois Gentilhomme of Moliere. The German writers, and even Dacier among the French, accuse him, however, of having, for the most part, spoilt the simple comic conceptions of the ancients, by accommodating them to modern manners, and by making the plots more artificial. We must recollect, that if this was a fault in Moliere, it was not easily avoided. By simply translating the plays of Plautus and Terence, he could not have pleased a modern audience had he given his classical drama in its naked simplicity. He has borrowed the idea of his "Avare" from the Aulularia of Plautus. Instead of a simple miser, he has given us a miser in love. On this charge it has been remarked, that the morale of the piece is not improved, but spoilt, because, if an old amorous dotard should go to the theatre and see the piece represented, he might say to himself, I care little for this satire, for I am not a miser; and if a miser, who happened not to be in love, should go to see it, he might, with equal justice say, "Very true, I am fond of money; but I thank my stars, I am not in love." We perceive nothing conclusive in this argument against the propriety of Moliere doubling comic effect by the conception of an amorous miser; and if it was not an improvement on classical simplicity, it was at least an agreeable variety, acquired by departing from it. In like manner we can read his Amphytrion without diminished admiration of Plautus; but still acknowledging that Moliere has made some departures from the original of considerable skill and felicity. The same cannot certainly be said of his Fourberies de Scapin, where the Phormio of Terence is by no means altered for the better. The French seem to consider his reputation as chiefly established on his "*Ecole des Femmes*," "*Tartuffe*," "*Misantrope*," and "*Femmes Scavantes*." The two last, we conceive, have too little amusing action to rank in the very highest class of comedies. But the Tartuffe, in spite of the objection of its too grave incidents, is a master-piece of deep drawn character. The Ecole des Femmes is certainly inimitable for its comic force, rapidity of movement, and for lively and original ideas. The Bourgeois Gentilhomme may perhaps be too farcical in the last acts, when the hero gives his daughter to the son of the Grand Turk, and becomes a Mamamouchi. But Monsieur Jourdain and his wife, and the cool-blooded courtier Dormine, with the whole contents of the three first acts, form a treat for the risible faculties, which, we believe, no production of the stage ever surpassed. The court of Louis the XIV. was so deplorably dull, as not to understand the humour of the piece when it was first acted; but the king had a better taste, and told Moliere, that he had never laughed so heartily in his life. The Court was converted to his opinion, and for once we can look on the authority of Louis the XIV. without regretting that it was arbitrary. The French Academy, for some time before the death of Moliere, wished to persuade him to give up the life of a comedian, that he might become a member of their society. After his decease, they voted him a public eloge, and placed his bust in their hall, with this inscription, expressive of regret that he had not become an academician,

"*Rien ne manque à sa glorie—il manque à la notre.*"

MOLLUSCA.

The history of the great division of animals to which the term Mollusca is now exclusively confined, was investigated in a very imperfect manner by the earlier naturalists. They attended merely to the characters furnished by the external appearance, and consequently formed their systematical divisions without regard to the natural affinities of the animals—affinities which can only be traced by an examination of the structure and functions of all the organs.

The first general attempt at classification, worthy of notice, appears in the twelfth edition of the *Systema Naturæ* of Linnæus. In this work, all the animals which were considered by the ancients as Exanguineous, and termed by the more recent naturalists, Invertebral, were, with the exception of insects, included in his sixth and last class, which he denominated *Vermes*, and assigned to it the following distinguishing characters.—*Cor*, uniloculare, inauritum; *Sanie* frigida. *Spiracula* obscura. *Maxillæ* multifariæ, variæ variis. *Penes* varii hermaphroditis Androgynis. *Sensus:* Tentacula (caput nullum, vix oculi, non aures, nares.) *Tegmenta* calcarea aut nulla, nisi spinæ. Fulcra: nulli Pedes aut Pinnæ. This class of vermes was again divided into four orders—*Intestina*, animalia simplicia, absque artubus, nuda. *Mollusca*, animalia simplicia, nuda (absque testa inhabitata,) artubus instructa. *Testacea*, animalia Mollusca, simplicia, domo, sæpius calcarea, propria obtecta. *Lithophyta*, animalia Mollusca, composita. Corallium calcareum, fixum, quod inædificarunt animalia affixa. *Zoophyta* animalia composita, efflorescentia. Stirps vegetans, metamorphosi transiens inflorens animal. The second and third orders, Mollusca and Testacea, include the animals to which our attention is to be directed in this article.

This systematical arrangement of Linnæus, while it contributed greatly to enlarge the number of species, had a tendency to divert the attention from the examination of their structure. The external form was exclusively employed to furnish the distinguishing characters, and was therefore chiefly regarded by the student, in reference both to genera and species. The relation between the external appearance, and the internal structure, not having been previously determined, these characters were obviously artificial, and the unnatural combinations which resulted from their employment, displayed themselves in every genus of any extent. In the same genus animals were to be found which respire in air, associated with those which perform the same function by means of gills in water; or animals whose gills are like leaves placed externally, with those having their gills in an internal cavity. Such incongruous combinations chiefly prevail among the vermes testacea, where the shell is exclusively employed in the determination of genera and species. There is another imperfection in this system, arising from the separation of the naked and testaceous mollusca into distinct orders. There is no such line of distinction observed by nature; and very considerable difficulties occur in its practical application as an artificial arrangement. Not a few animals included in the testacea, as the Bulla aperta, have the shell so concealed under the skin, that it can only be rendered visible by the separation of the softer parts; and several animals, included among the naked mollusca, are covered, in particular places, by a corneous or shelly plate, as the Aplysiæ. In consequence of these circumstanecs, genera which are nearly related are placed in different orders, while those which possess few common properties are grouped together.

Independent of these objections, which have been made against the Linnæan classification of molluscous animals, it is still pertinaciously adhered to by many British naturalists. This influence of the *idolum theatri* is the more to be regretted, as it has retarded the progress of science, limited the field of observation, and prevented us from availing ourselves of the improvements which have resulted from the labours of our continental neighbours.

For many years the influence of the artificial method of Linnæus, in botany, had been successfully assailed in France; and the followers of the natural method at length became so numerous as to secure it a favourable reception. Various efforts were likewise made to promote its introduction into the science of zoology. This was at length triumphantly effected, in regard to molluscous animals, by M. G. Cuvier. Other enquirers, it is true, largely contributed to the accomplishment of this desirable end: three of whom, distinguished by their patient industry, deserve to be particularly enumerated, Adamson, Muller, and Poli. The former paved the way to the modern arrangements, in his *Historie Naturelle du Senegal.* Muller explored the molluscous animals of Denmark, and published the result of his observations in the *Zoologia Danica*, and his *Vermium Terrestrium et Fluviatilium Historia.* Poli, directing his attention to the structure of the animals inhabiting the multivalve and bivalve shells, published his laborious observations in his *Testacea utriusque Siciliæ eorumque Historia et Anatomie.* Many other authors might be enumerated, who have likewise contributed to extend our knowledge of the structure of molluscous animals, as Lister, Monro, and Home; but as we shall have occasion afterwards to advert to their labours, it is unnecessary to enter into further details.

The first efforts of Cuvier to illustrate this department of zoology, though necessarily imperfect, excited the attention of naturalists to the subject, and were the prelude to those mighty achievements, more recently made known to the world in his various papers inserted in the *Annales du Museum*, and republished under the title *Memoires pour servir à l'Histoire et à l'Anatomie des Mollusquès*, in one volume quarto, Paris, 1816. These papers may be considered as models of minute and accurate research, perspicuous description, and candid criticism, and merit the careful and frequent perusal of the student of molluscous animals. In the second volume of a more recent work by the same author, entitled *Le Règne Animal destribue d'apres son Organization*, Paris, 1817, he has given a synoptical view of the subject, which we intend to make the basis of the following article.

As a preliminary step to an examination of the divisions of molluscous animals, we shall take a very general view of their structure and functions, reserving the more minute details to be given under the different groups into which they have been arranged. Indeed, the several organs, as they appear in the different tribes, are so variously modified, that few common properties can be enumerated. In this section, however, we shall be able to mark the course to be observed in the illustration of the subordinate divisions, endeavouring, at the same time, to avoid saying any thing which will again require to be repeated.

1. *General Form.*—The molluscous animals exhibit very remarkable differences in their form, and the number and position of their external members. Neither head nor foot can be observed in some, the principal organs being enclosed in a bag pierced with apertures for the entrance of the food and egress of the excrementitious matter. In some, whose exterior is still remarkably simple, cuticular elongations, termed tentacula, surround the mouth, and a foot, or instrument of motion, may likewise be perceived. This last organ is in some free at one extremity, in others attached to the body throughout its whole length. In many species there is a head, not, however, analogous to that member in the vertebral animals, and containing the brain and organs of the senses, but distinguished as the anterior extremity of the body, separated from the back by a slight groove, and containing the mouth and tentacula.

In many of the animals of this division, the different members of the body are in pairs, and are arranged, in reference to a mesial plane, into right and left. In some, part of whose organs respect a mesial plane, other parts are single, or in unequal numbers. In other species, the organs, which are not in pairs, are arranged round a central axis, and give to the external form a radiated appearance. But these characters are exceedingly variable and uncertain, as marking the limits of particular tribes; since, in different parts of the same animal, modifications of these forms may be readily distinguished.

2. *Cutaneous System.*—The skin of molluscous animals is more simple in its structure than the same organ in the vertebral animals. The *cuticle* is here very distinct; and, as in other classes, it is thick and coarse, where much exposed, but thin and delicate in its texture, where it lines the internal cavities. A *mucous* web may be detected in the cuttle fish and slug, but of great tenuity. The *corium* is destitute of a villous surface; and on its central aspect it is so intimately united to cellular substance, that its fibrous structure can scarcely be distinguished. The *muscular* web may, in general, be readily perceived. Its fibres proceed in various directions, according to the kind of motion to be executed, and extend or corrugate the skin at pleasure.

The appendices of the skin in this class of animals ought to be carefully studied, as they furnish the most obvious marks for distinguishing species, and for constructing divisions in their systematic arrangement. The appendices of the cuticle are few in number, and perhaps ought to be considered as limited to *hairs.* These, in some species, invest the surface regularly and closely, and may be observed on those which live on land, as well as those which reside in water. In some cases these hairs are as it were united, to form continuous crusts or ridges. These hairs, as well as the cuticle, are liable to be worn off, and in some places can seldom be perceived, unless in early age.

The most important appendix of the skin appears to be *shell.* This part is easily preserved, exhibits fine forms and beautiful colours, and has long occupied the attention of the conchologist. The matter of the shell is secreted by the corium, and the form which it assumes is regulated by the body of the animal. It is coeval with the existence of the animal, and appears previous to the exclusion from the egg; nor can it be dispensed with during the continuance of existence. The solid matter of the shell consists of carbonate of lime, with a small portion of animal matter, resembling coagulated albumen.

The mouth of the shell is extended by the application of fresh layers of the shelly matter to the margin, and its thickness is increased by a coating on the inner surface. These assertions are abundantly confirmed by the observations of Reaumur, (*Mémoires de l'Académies des Sciences*, 1709.) whose accurate experiments have greatly contributed to the elucidation of conchology. If a hole is made in the shell of a snail, and a piece of skin glued to the inner margin, so as to cover the opening, the shelly matter does not ooze out from the broken surface, so as to cover the external surface of the skin, but it forms a coating on its inner surface, thus proving it to have exuded from the body of the animal. When a considerable part of the oral part of the spire of a snail is broken off, and a piece of skin glued to the inner margin, and reflected outwardly and fixed on the body of the shell, the spire is again renewed, and the matter added to the inner surface, thus leaving the skin interposed between the new formed portion and the fractured edge. Similar experiments, repeated on a variety of shells, both univalve and bivalve, by different naturalists, leave no room to doubt that shells increase in size by the juxtaposition of shelly matter from the common integuments.

Each calcareous layer is more or less intimately mixed and enveloped in the animal matter, which we have already alluded to; so that the different layers of successive growth may, by various processes, be distinctly exhibited. If the shell is exposed for a short time in the fire, the animal matter becomes charred, and its black colour, contrasted with the white earthy matter, indicates the different strata: in the same manner as the ivory and enamel of a tooth can be distinguished, when subjected to similar treatment. The same satisfactory results may be obtained by a different process. If the shell be steeped in weak muriatic acid, the earthy matter will be dissolved, and the flakes of albumen will remain as the frame-work of the edifice.

The layers of growth may often be distinguished on the surface of the shell, in the form of striæ, or ridges more or less elevated, but parallel to the margin of the aperture. Other inequalities may likewise be observed on the surface, at right angles to the layers of growth, such as ridges, knobs, and spines. These last derive their origin from the inequalities of the skin on which they have been moulded.

In some univalve shells, the layers of growth parallel to the opening cannot be discerned; when exposed in the fire, there is little darkening of colour; and when dissolved in acids, but a feeble trace of animal matter remains. In the fire, these shells crack in various directions, but exhibit no trace of a scaly structure. By a careful management with the file, the shell may be separated into a central layer contiguous to the skin, and a peripheral layer, both similar in structure, though frequently differing in colour. The shells exhibiting such characters have been termed *Porcellaneous*, from their dense structure, and the fine polish which their surface presents. The formation of shells of this kind must be executed in a different manner from those of the first kind which we have noticed.

If we attend to the form of a young shell of the genus Cypræa of Linnæus, we may perceive that an addition of shelly matter to the margin of the aperture, in the manner in which it is applied in other shells, would not enlarge the cavity, but completely close the aperture. The increase of the shell, (accompanied with a corresponding increase of its inhabitant,) must take place either by absorption of the accumulated shelly matter of the mouth, and an elongation in the direction of the greatest curvature of the shell; or the old shell must be thrown off, and a new one produced, suited to the size of the animal. The former supposition has not been entertained, the latter is now generally received by naturalists. The inner coat of such shells appears to be a transudation from the body of the animal, the outer one applied to the surface by the loose reflected lobes of the cloak. In many other shells, portions of more compact matter than the other parts may be observed, spread on the pillar, and applied to the margin of the mouth by a similar process. Mr. Platt, in support of Reaumur's opinion, that shells are formed by juxtaposition, against the objections of Mr. Poupart, (*Phil. Trans.* vol. liv. p. 43.) erroneously considers the different sizes of the Cypreæ as depending on the thickness of the shell increasing according to age, without admitting a corresponding increase of the dimensions of the contained animal, or cavity for its reception.

The shells of the first kind which we have noticed, from the manner in which they are formed, of cones or layers applied to the inner edge of the margin, and extending beyond it, have an imbricated structure. Those of the second kind, consisting of layers regularly superimposed, have consequently a laminated structure; but between the two kinds there are numerous intermediate links, formed by a combination of the two processes.

In some cases, the hard parts of the skin are not entitled to the appellation of shell, but may rather be considered as horn. Such are the coverings of the mandibles of the Cuttle-fish, the branchial lid of the Aplysia, and the operculum of the Welk. The two last appendices, however, though horny in some species, are shelly in others.

The position of the shell with respect to the constituent layers of the integuments, exhibits very remarkable differences. In some it appears instead of a cuticle, or at least external membrane investing it. In general, however, it occurs between the cuticle and the skin, a position which induces Cuvier, *Lec. d'An. Comp.* xiv. 11.) to consider it as analogous to the mucous web of the vertebral animals. Its intimate connection with the muscular system of the animal, and the protection which it yields, seem adverse to such a conclusion. In many species the testaceous substance occurs in folds of the corium, or inserted in its substance. In this position it never acquires the solid texture which shells exposed, or covered only by the cuticle, exhibit. Those which are thus concealed are in general white; those which are more exposed are frequently coloured. The colouring, however, does not depend on the direct exposure to the light, as some have imagined, for many shells which are destitute of a cuticle are white, while many of those covered with a dense cuticle are finely variegated beneath. The forms of the British species of shells have been described in detail under the article Conchology, where an explanation of the terms by which their different parts are distinguished may likewise be found.

Between the skin and the shell neither vessels nor nerves have been traced; and the manner in which the latter is formed forbids us to expect their existence. Yet the shell cannot be considered as dead matter, so long as it remains in connection with the living animal. In those animals in which the shell is external, there are muscles which connect the animal with its internal surface, and the bond of union being a substance soluble in water, the muscle can be detached by maceration. The analogy between shell and bone is here obvious, although in the one case the connection between the muscle and the bone is permanent, in the other between the muscle and shell temporary, or frequently changed during the life of the animal. But the vitality of the shell, if I may use the expression, is demonstrated from the changes which it undergoes when detached from the animal: The plates of animal matter harden; the epidermis dries, cracks, and falls off; and, in many cases, the colours fade or disappear. We confess ourselves unable to point out the means employed by the animal to prevent these changes from taking place, by any process similar to circulation. It is probably effected by the secretions of the skin, in the same manner as our cuticle and hair are lubricated. When the shelly covering consists of two or more pieces, they are joined together as the articulated bones in the higher classes of animals, by ligaments. These, in some cases, are of great thickness and strength, and, in consequence of their elasticity, assist in the motion of the different parts.

In the molluscous animals, the skin secretes a viscous, adhesive substance, differing according to the medium in which the animal resides, but in all cases calculated to resist its influence. It is probably owing to the lubricating agency of this secretion, that both the cuticle and shell are preserved from decomposition.

The skin likewise secretes the colouring matter by which the shells are variegated. The glands from which it proceeds vary much in different individuals, and even in the same individual in different periods of growth.

The characters furnished by the skin and its appendices, are extensively employed in the systematical arrangement of molluscous animals; nearly all those characters which distinguish the species, and many of those on which genera are established, are derived from the form of the shell, the tentacula, or the colour. This last character, however, is one on which little dependence should be placed.

3. *Muscular System.*—There is nothing peculiar in the muscular system of this class of animals. Where the muscles are inserted in the skin, as is usually the case, that organ is in some cases strengthened by condensed cellular substance; where the muscles are inserted on the shell, although no intervening tendons can be perceived, the existence of a connecting link of a similar nature is rendered probable by the circumstance of boiling water not dissolving the muscle itself, yet detaching it from the surface of the shell. During the growth of the animal, such detachment is frequently performed voluntarily, as it increases in size, and alters its position with regard to the shell.

Molluscous animals preserve themselves in a state of *rest* chiefly by suction and cementation. The organ which acts as a sucker, is in some cases simple, soft, and muscular, as the foot of the snail, while in others it is compound, and strengthened internally by hard parts, as in the arms of the cuttle-fish. The force with which some animals adhere is very considerable, and is strikingly displayed, for example, when we attempt to detach a limpet from the rock.

The rest, which is maintained by cementation, in some cases depends on a glairy secretion, which glues the body of the animal to the substance to which it is disposed to be attached. By such an expedient, the shells of snails adhere to rocks, stones, and plants. It is probable that the bivalve shells of the genus Cyclas, which readily adhere to the sides of a glass, obtain their temporary attachment by means of their glutinous cuticle. In other animals threads are produced, (termed a *Byssus*,) from particular glands, and while one extremity is glued to the rock, the other remains in connection with the animal. But there is an attachment more durable than any of these, which takes place in some shells, they being cemented to rocks or stones by calcareous matter, and retained in the same position during the whole term of their existence.

The locomotive powers of the mollusca are confined to creeping and swimming. The former action is performed by alternate contraction and relaxation of the foot, or muscular expansion, which serves as a sucker, and is analogous to the motion of serpents. The motion of swimming is executed either by the serpentine undulations of the foot and the body, or by the action of tentacula, or expanded portions of the integuments. Many species are aided in swimming by being able to vary the specific gravity of their body at pleasure, and either rise or sink in the water, as circumstances may require. In some, as the Janthina, there is a cellular organ peculiarly destined for this purpose, which may be regarded as in some measure analogous to the air-bladder of fishes. In all these exertions, their progress is proverbially slow. Some bivalve shells have the power of *leaping*, or shifting their position by a sudden jerk, produced by shutting the valves rapidly. This is strikingly displayed in the common Scallop, and is less perfectly exhibited in the river mussels. In a few instances, especially among the slugs, a thread is formed of the viscous secretion of the skin, by which the animal is enabled to suspend itself in the air from the branches of trees.

Although the progressive motions of molluscous animals are comparatively slow, the other muscular actions are executed with ordinary rapidity. The irritabilility of some parts, as the tentacula and branchiæ, is so great, that the protecting movements are executed almost instantaneously, and the organs are contracted or withdrawn into the body. But these rapid exertions are only called forth in the moments of danger; the ordinary movements are all executed with characteristic slowness.

The characters furnished by the muscular system are of great value in the discrimination of species, and in the construction of genera and higher divisions. They are intimately connected with the habits of the animal, and merit the attentive examination of the philosophical naturalist.

4. *Nervous System.*—In the molluscous animals, the nervous system is less complicated in its structure than in the higher classes, and the brain is not restricted in its position to the head. The whole nervous system appears in the form of ganglia and filaments. The principal ganglion, or the one to which the term brain is usually applied, is seated above the gullet or entrance to the stomach. It sends out nerves to the parts about the mouth, to the tentacula, and to the eyes. It may

be considered as analogous to the cerebrum of the vertebral animals. From this ganglion proceed two filaments, one on each side, which, in their descent, inclose the gullet, and unite underneath to form a second ganglion. From this last, which has been compared to the cerebellum, numerous filaments are likewise distributed to the parts around the mouth, and to the other regions of the body. These filaments in some cases again unite, and form subordinate ganglia. In many cases the brain and ganglia are of a white colour, and granulated structure; while the nerves which issue from them are white and uniform. The covering of the first ganglion, which is analogous to the *dura mater*, does not adhere to it closely, but leaves a space filled with loose cellular matter. The tunics of the nerves are equally detached; and as they can be inflated or injected readily, they have led some to suppose that the nerves were hollow, and others, that the tunics were the vessels of the lymphatic system.

The organs of perception, common to the higher classes of animals, do not all exist in an obvious manner among the mollusca. The *touch*, that universal sense, is here displayed in many cases with great delicacy; and the tentacula, and other cuticular elongations which we have already referred to, contribute to augment its resources. The sense of *sight* is by no means universally enjoyed by the inhabitants of this class. In a few species the eye is constructed on the plan of the same organ in the vertebral animals. In general, however, it appears only as a black point, whose peculiar functions can only be inferred from analogy. In many animals there is no trace of an eye, consequently they cannot possess that varied information which the higher animals obtain from that organ. Where eyes exist in this class, they are uniformly two in number. In one tribe only, namely, the cuttle-fish, have the rudiments of the organs of *hearing* been detected. The organs adapted to *smelling* cannot be exhibited, but the existence of the sense is demonstrated by the facility with which they discover suitable food, when placed within their reach. The sense of *taste* exists, but it is difficult to point out the particular parts of the mouth fitted for its residence. But as they select particular articles of food in preference to others, we reasonably conclude that taste regulates the choice.

It is difficult to form an accurate estimate of the knowledge of external objects which molluscous animals can obtain by means of their organs of perception, joined to their powers of locomotion. The kind of life which they enjoy is so widely different from our own; and attempts to tame them, or vary their habits by education, are limited by so many circumstances, that we must ever remain in ignorance of their mental powers or capabilities. M. Lamarck ranges them among his *Animeaux Sensibles*, and considers that, by means of their sensations, they acquire only perceptions of objects, or simple ideas, which they are incapable of combining by any mental process. Had this opinion rested on observations, or even on arguments, it might have been worth while to controvert it, but, as it forms a part of the metaphysical speculations of that zoologist, built upon gratuitous assumptions, it requires no farther notice.

In the classification of the mollusca, the characters furnished by the nervous system, from the difficulty of their detection and exhibition, have never come into use. But those furnished by the organs of perception are highly prized. Of these, the eye is the most obvious and constant. It varies in position in different species; but among individuals of the same species its characters are constant.

5. *Digestive System.*—In the cutaneous, muscular, and nervous systems, traces of a general plan may be observed, according to which they have been constructed in the different tribes. In the organs which remain to be considered, there is less uniformity of structure, each family, almost, being constructed according to a model of its own.

The time when molluscous animals feed has not been carefully attended to. Those which live in the water are beyond the reach of accurate observation. Those that reside on land usually shun the light, and creep forth in the evenings to commit their depredations. During warm dry weather, they stir not from their holes.

The animals under consideration feed equally on the products of the vegetable and animal kingdom. Those which are *phytivorous* appear to prefer living vegetables, and refuse to eat those which are dried. We are not aware that putrid vegetable matter is consumed by them, although many of the snails and slugs are found under putrid leaves and decayed wood. In these places there is shelter from the sun, together with dampness, so that it is difficult to determine whether they sojourn in an agreeable dwelling, or a well-stored larder. Those mollusca which are *carnivorous*, prey on minute animals in a living state, and many of them greedily attack putrid matter.

The means employed by molluscous animals to bring the food within the reach of the organs of deglutition, are exceedingly interesting, both on account of their variety and success. Some are provided with tentacula for securing their prey, and conveying it to their mouth, as the cuttle-fish; others protrude a lengthened proboscis, or an extended lip or tongue, and thus bring their food into the mouth. With many, however, which are fixed to the same spot during the continuance of existence, or only capable of very limited locomotive power, successful efforts are made by the animal to excite currents in the water, (for no permanently fixed animals reside on land,) whereby fresh portions of it are brought in contact with the mouth, and its animal or vegetable contents separated. This action is performed in some cases, as among the bivalves, by the mechanical action of the valves of the shell, aided, in many species, by the syphons, while, in others, it is excited by the motion of articulate feet, as in the bernacles. Where part only of any kind of food is taken into the mouth at once, the lips are possessed of sufficient firmness to cut off the requisite portions, or there are corneous mandibles to perform the office.

In the mouth there is scarcely any process performed analogous to that of mastication in the higher orders of animals. When the food is in the mouth, or entering into the gullet, it is mixed with saliva, as in the more perfect animals. The *salivary glands* in which it is secreted are, in general, of considerable size, divided into lobes, and, in some cases, separated into distinct masses. In many species the existence of a gullet is doubtful, as the food seems to enter the stomach immediately; while, in others, there is a portion of the intestinal canal which has some claim to the denomination.

The stomach, in many cases, is membranaceous, and can scarcely be distinguished from the remaining portion of the intestinal canal. In some cases, however, it is strong and muscular, like the gizzard of a bird, and even fortified with corneous knobs for the reduction of hard substances. In some species the stomach opens laterally into the pylorus, and, in a few instances, possesses a spiral cecum attached to it.

The *liver* in the mollusca is usually of large dimensions, and seated close to the stomach, which it in many cases envelopes. It is divided into numerous lobes, and receives numerous blood vessels. There is, however, nothing analagous to the *vena portarum* of quadrupeds. The *bile* is poured in some into the stomach, and in others into the pyloric extremity of the intestine by different openings. There is no gall-bladder.

There is no division of the canal into small and large intestines, as in the higher classes; or rather, among the mollusca, the relative size of the different parts is reversed. Here the pyloric extremity is usually the largest, while the anal is more slender. The intestine, like fishes, is short in proportion to the length of the body, and, in its course, is subject to few turns. The anus is, in some, placed on one side of the body; in others it is terminal, while, in a few, it opens on the back.

The digestive system is thus more simple in its structure than in the higher classes. It possesses neither pancreas, spleen, nor mesentery. The calls of hunger are often at distant intervals, and the power of abstinence is great.

The characters furnished by the digestive system are extensively used in the inferior divisions of molluscous animals. The form of the lips, the position of the mouth and anus, and the structure of the stomach, deserve to be attentively considered, as indicating the habits of the species.

6. *Circulating System.*—The mechanical process by which the food is converted into chyle has not been satisfactorily traced, nor has the existence of lacteals for the absorption of the chyle been demonstrated. In this class of animals, the veins seem to perform the offices both of lacteals and lymphatics.

The blood in this tribe of animals is white, or rather of a bluish colour. Its mechanical and chemical constitution have never been successfully investigated.

In the employment of the words right and left, to express the relative position of the cavities of the heart in the inferior animals, much confusion must necessarily arise; or rather, other terms must be used to render our descriptions intelligible. The nomenclature of that learned anatomist, Dr. Barclay, appears to obviate all difficulty in reference to the ambiguity of words indicative of position, and to convey in its expressions an idea of the uses of the vessels which are alluded to. Thus the *pulmonic* vessels include all those which bring the blood collected from different parts of the body to the lungs, such as the vena cava, right auricle, right ventricle, and pulmonary arteries. The *systemic* vessels are those which convey the blood from the lungs to the different parts of the body, including the pulmonary veins, left auricle, left ventricle, and aorta. It is our intention to employ these terms as we proceed.

The circulating system of molluscous animals exhibits very remarkable differences in the different classes. In all of them, however, there is both a systematic and a pulmonic system of vessels, as in the higher classes of animals. They may be divided, in reference to their circulating system, into four groups. In the first, the blood is collected from the different parts of the body into a *vena cava*. This vein is divided into two branches, to each of which there is a ventricle attached, and from each ventricle an artery proceeds to the gills or lungs in its neighbourhood. Each of the two divisions of the lungs gives rise to a vein; these terminate in a single ventricle, from whence the blood is transmitted to the different parts of the body. There are here one systemic and two pulmonic ventricles. This arrangement prevails among the *cephalopoda*.

In the second group, the vessels in which the blood has been collected from the different parts of the body proceed directly to the lungs or gills, without the intervention either of auricle or ventricle. The systemic veins which have absorbed the blood from the lungs pour it into an auricle, from whence it passes into a ventricle, to be distributed throughout the body. Here, then, there are neither pulmonic auricles nor ventricles, while there is one systemic auricle and ventricle. This dristribution prevails among the gasteropoda, pteropoda, and inequivalve conchifera. In these last, however, as the oyster and scallop, the auricle is bilobate, making an approach to those of the following division.

In the third group, like the second, there are neither pulmonic auricles nor ventricles, the pulmonic veins proceeding directly to the lungs or gills. The systemic veins, however, terminate in two auricles, these empty their contents into one ventricle; so that there are two systemic auricles and one systemic ventricle. This structure appears in the equivalve *conchifera*.

In the fourth group there are no pulmonic auricles or ventricles, neither systemic auricle; but there are two systemic ventricles. This includes the animals of the *brachiopoda*.

In the last group no pulmonic auricle or ventricle, neither systemic auricle, can be perceived; but there is a single systemic ventricle. Animals of the class *tunicata* exhibit this simple arrangement.

The circulating system furnishes few characters which can be employed in systematical arrangements. The structure of the systemic and pulmonary vessels does not appear to be co-ordinate with any particular plan of external configuration and manner, as we see in the case of the pteropoda and gasteropoda. In these the organs of circulation are very much alike, while the external forms exhibit very obvious differences.

7. *Respiratory System.*—It is probable that all animals, however imperfect, stand in need of a supply of oxygen. In proportion as the circulating system becomes complex, the greater is the quantity of oxygen which is required. In the more perfect animals it has been ascertained, that this oxygen unites with carbon thrown out of the system, and, by converting it into carbonic acid, enables it more readily to escape in the gaseous form. In some animals this production of carbonic acid takes place generally throughout the surface of the skin, while in others particular organs are appropriated to its formation. This is more particularly the case in those animals which, like the mollusca, have pulmonic and systemic blood-vessels When the animal separates the oxygen from unmixed atmospheric air, the organ in which the process is performed is termed *lung*. When the separation takes place in atmospheric air united with water, the organ is termed a *gill*.

The molluscous animals which respire by means of lungs are few in number, and form a very natural tribe, which Cuvier has termed *gasteropodes pulmones*. In them the respiratory organ is simple, consisting of a single cavity, on the walls of which the extremities of the pulmonary artery are spread. This cavity is placed somewhat laterally, and communicates externally by an aperture which the animal can open or shut at pleasure.

The mollusca which breathe by means of gills, exhibit very remarkable differences, in their number, structure, and position. In some cases there is a single cavity communicating by an aperture through which the water enters. The walls of this cavity exhibit an uneven surface, disposed in ridges, which are the gills, and on which the pulmonic artery is expanded. This structure exhibits itself in the Gasteropoda pectini-branchia.

In many cases the gills, though seated in a cavity, like the former, and equally exposed to the contact of the surrounding element, are two in number, one on each side, as in the Cephalopoda. In the Conchifera they are four in number, two on each side, like leaves, and extending the whole length of the body. In these the water is admitted at the pleasure of the animal.

The gills of other mollusca are seated internally, and consist either of arborescent productions, or simple cuticular elongations, within which the pulmonary artery terminates. In some of these, as the Pteropoda, the branchial surface is constantly exposed to the action of the surrounding water; while in others, as the *Gasteropoda, nudibranchia*, and *tectibranchia*, the cuticular expansions, which are analagous to gills, are retractile at the will of the animal.

By means of the characters furnished by the circulating and respiratory systems, the molluscous animals may be divided into several distinct classes. But as we shall employ these characters in the construction of the different divisions to be employed, it is unnecessary, in this place, to enter into their details.

8. *Reproductive System.*—The animals now under consideration present nearly all the modifications of generation which organized bodies exhibit. They are not indeed known to produce their young like buds, as in the fresh-water polypus (Hydra,) nor to multiply by the spontaneous division of individuals, as some Nereidæ and Planariæ. But the three following modes of reproduction have been detected.

In the first the sexes are distinct, as in the higher classes of animals. This mode is exhibited in the Cephalopoda and some Gasteropoda. In the former, however, there is no union of the sexes previous to fecundation. The eggs are first excluded by the female, and the male afterwards covers them with the impregnating fluid, after the manner of fishes. In the Gasteropoda, with the sexes distinct, a union takes place by which the eggs are fecundated. After impregnation, the eggs are either excluded previous to the young issuing from them, or retained in the body of the animal until they are hatched.

In the second the sexual organs are distinct, but they both occur in the same individual; here, however, a union of two individuals is necessary, during which each impregnates and is impregnated. The snail and slug may be quoted as examples.

In the third mode of generation, which may be regarded as the most complete hermaphroditism, there is neither a difference of sex, nor an obvious difference of sexual organs. All that can be detected, is connected with the female parts, and no union of individuals is requisite. This is the mode of generation exhibited by the Gasteropoda scuti-branchia and cyclo-branchia, by the whole of the Conchifera and Tunicata.

In the first division of the first tribe, the female possesses an ovarium and oviduct, and the male a testicle, vas deferens, seminal bag, prostate gland, and penis, together with some accessary organs, whose uses have not been ascertained. In the second division of the first tribe, there is in the female an ovarium oviduct and uterus, and in the male a testicle, vas deferens, and penis.

In the second division, the female organs consist of an ovarium oviduct and uterus, and the male of a testicle, vas deferens, pedunculated vesicle and penis. These organs, all occurring in the same individual, have their openings in what is termed the common cavity of generation, which opens externally. The use of the pedunculated vesicle is not determined. In some species it is attached to the male organs, in others to the female, or to the common cavity.

In the last division, the ovarium is the principal and only organ of generation. In some species it is difficult to discover an oviduct, while in others, not only the oviduct, but its external termination, may be readily traced.

The organs of generation furnish many important characters for classification. The external openings are those which are detected with the greatest facility, but the structure of the internal organs exhibits more varied and driscriminating marks.

9. *Peculiar secretions.*—The molluscous animals are considered as destitute of organs for the production of urine, but they possess various organs for the secretion of peculiar fluids or solids, some of which are useful in the arts.

The coloured fluid, which is secreted by the Cephalopoda and some of the aquatic gasteropoda, appears to consist chiefly of a peculiar mucus united to a pigment whose properties have not been sufficiently investigated. The animals which furnish this secretion, eject it when in danger or irritated, and thus envelope themselves in a dark cloud, and elude the pursuit of their foes. A milky secretion is poured forth over the surface of the skin of some slugs when irritated. Other coloured secretions may likewise be detected in the mollusca, to which we shall afterwards advert.

The threadlike secretions, termed a *byssus*, with which some molluscous animals, especially among the Conchifera, fix themselves to other bodies, appear to be of an albuminous nature. A few species in this division have the power of secreting a *luminous* fluid, which phosphoresces or shines in the dark. Its nature, and the organs in which it is elaborated, have not been investigated. It is probable that some animals, as those which have the faculty of raising or lowering themselves in the water, have likewise the power of secreting *air* into those organs which contribute to their buoyancy. The Janthina vulgaris may here be quoted as an example.

Morbid secretions likewise occur among the animals of this division, chiefly, however, among the Conchifera. The most important of these are *pearls*, so much prized as ornaments of dress.

10. *Condition of the Mollusca.*—Molluscous animals are divided, according to the situation in which they reside, into three groups, which may be termed terrestrial, fluviatile, and marine. Those that inhabit the land belong exclusively to the Gasteropoda. Among these, some prefer open pastures, others the rubbish of old walls, while not a few reside in woods, or among dead leaves and putrid plants. All the animals of this group respire by means of a pulmonary cavity.

The fluviatile mollusca, or such as reside in fresh waters, include not only many Gasteropodous genera, but likewise some belonging to the Conchifera. Among these, some breathe air by means of a pulmonary cavity, and come to the surface to respire. Such species frequent the more shallow ponds and lakes. Others, respiring by means of gills, are less dependent on the shallowness of the water, and consequently reside in different depths.

The marine mollusca include genera of all the classes. Some, as many of the Cirrhipoda, instead of living in the water, prefer a situation where they may only be bathed occasionally with the flood tide. Others burrow in the sand, or adhere to the rocks which are left dry by the receding tide. These are termed littoral species. Many, however, which have been denominated pelagic, reside in the deep, and are seldom obtained but by dredging, or when thrown ashore during storms.

The effect of temperature in regulating the distribution of molluscous animals has not been investigated with any degree of care or success. Over the terrestrial and fluviatile species it probably exercises a very powerful control, greatly limiting their geographical range. In proof of this, it may be stated that the south of France possesses several species not to be found in England, while in England there are a few which have not been detected in Scotland. But among the marine mollusca, the influence of climate is not felt in the same degree. Living in an element whose bulk and motions guard it equally from the extremes of heat or cold, these animals, like the sea-weeds, have a very extensive latitudinal and longitudinal range. Thus, some are common to Greenland and the Mediterranean, others to Britain and the West Indies. The mollusca of the tropical seas, however, differ widely as a whole from those of the temperate regions. Some of the forms appear to be peculiar to warm regions, and in general the intensity of colour decreases as we approach the poles. But as there have been few cultivators of this branch of science, the geographical distribution of the species has been but imperfectly explored. How few parts of either England or Scotland have been surveyed by the eye of the helmonthologist, so that many species whose range is considered as limited, may ere long be found to be extensive.

If the observations are few and imperfect, which have been made on the influence of temperature in regulating the physical distribution of mollusca, we are still in greater ignorance with regard to the power of habit. In the flœtz rocks, the relics of marine and fluviatile mollusca are found mixed in the same bed. This circumstance gave rise to the inquiry, how far the mollusca of fresh water can be habituated to sea water, and *vice versa*. In the account of the proceedings of the National Institute of France for the year 1816, we are informed that M. Beuchant, Professor at Marseilles, has directed his attention to this subject. He found that all these animals die immediately, if we suddenly change their place of abode; but that, if we gradually increase the proportion of salt in the water for the one set, and diminish it for the other set, we can, in general, accustom them to live in a water which is not natural to them. He found, however, some species which resisted these attempts, and which could not bear any alteration in the quality of the water in which they reside. Before much confidence can be placed in the accuracy of these results, it would be desirable that the experiments were repeated by other observers. There are, indeed, many sources of error to be guarded against. When we change animals from fresh to salt water, or from salt water to fresh, we must necessarily derange their motions, by compelling them to reside in a medium of a different degree of density from the one which they have been accustomed to dwell in, and to which the arrangement of the different parts of the body is adapted. By such a change of place, it would be difficult for those which breathe air to come to the surface, and descend again in their new situation. In those with gills, the application of a new kind of fluid to the surface of such delicate organs would considerably influence the function of respiration. The change of situation would likewise be accompanied by a corresponding change of food, and consequently, not merely the organs of locomotion and respiration, but likewise those of digestion, would suffer a derangement in their operations. We know that the power of *suffering* in the animals of this class is very great, and that they survive, though sadly mutilated. Some of the snails will live in a quiescent state for years, without food, and almost without air. Unless, therefore, the animals subjected to these experiments of a change of situation have been observed to grow on the food which it spontaneously yields, to execute their accustomed motions, and, above all, to propagate their kind, we shall be disposed to conclude, that patient suffering has been mistaken for health, and vivaciousness for the power of accommodation.

As connected with the physical distribution of molluscous animals, we may here offer a few observations on the revolutions which they have experienced. From the oldest secondary rocks to the newest alluvial deposits, the remains of the hard parts of these animals may be observed. In the newer situations, these parts are less altered than in the older ones, in which they are frequently changed into calcareous spar, clay, flint, or pyrites. The forms exhibited by the remains in the older rocks are different from those in the newer ones, and intimate that they have belonged to races now no longer existing on the surface of the globe. These remains do not characterize any particular beds or formations, different beds often producing similar remains, and similar beds containing dissimilar fossils, intimating that the physical and geographical distributions of these animals in the earlier parts of the earth's existence, were regulated nearly by the same laws which prevail at present. But into this interesting subject it is impossible at present to enter.

The molluscous animals furnish an agreeable repast to many quadrupeds, birds, and fishes. To man they yield a great deal of palatable and nutricious food. Those which inhabit the sea are held in the highest estimation, while the terrestrial and fluviatile races are generally neglected.

The manner of preparing and preserving the hard parts of the mollusca, has been already given in sufficient detail in the conclusion of our article Conchology, to which we refer the reader. There is only one method of preserving the softer parts—immersion in spirits of wine. But in the execution of this plan some caution is requisite, otherwise the object will appear a shrivelled shapeless mass. The animal should be permitted to die slowly, that the different parts may become relaxed, otherwise the examination of the form of the body at a future period becomes impracticable. A quantity of the spirits ought to be injected into the stomach or other cavities of the body immediately after death, to prevent putrefaction, as it frequently happens, when the body is immersed in spirits without such precaution, that the viscera become unfit for examination, while the integuments remain sound.

In the following general view of the different classes into which molluscous animals have been divided, we shall follow the arrangements of M. Cuvier, modified by the systematical labours of M. Lamarck. Frequent reference will be made to species, natives of the British isles, to enable the curious reader to comprehend the recent improvements which have been effected in this branch of natural history.

I. CLASS.—Cephalopoda.

The animals which are included in this class, are familiarly known by the name of *Cuttle-Fish.* They attracted the notice of the ancients by their curious forms and manners, and appear to have been examined by Aristotle with minute attention.

The cephalopoda, in reference to their external appearance, may be regarded as consisting of two parts. The tunic or sac, which contains the viscera, and the head surrounded by the tentacula. The sac is in some species in the form of a purse, destitute of any appendages, while in others it exhibits fin like expansions. It varies considerably in its consistence, and in some it is strengthened on the back internally by corneous ribs or testaceous plates, in others protected externally by spiral shells. In some species it is connected with the head by an intervening space, which may be regarded as a neck, but in others the tunic and head are continuous behind. In all, it exhibits after death great changes of colour.

On the summit of the head there is a flattened disk, in the centre of which is seated the mouth. Round the margin of this oral disk, which is strengthened by a band of muscular fibres, are placed the arms or tentacula. Beyond this circle of arms, in some species, there are situated two organs, larger in their dimensions than the arms, which may be denominated feet. Both the arms and feet are covered on their central aspect with numerous suckers, by which they are enabled to attach themselves to different bodies, and to seize their prey, and in their axis both a nerve and artery may be observed. These arms and feet are capable of being moved, at the will of the animal, in every direction, and are the organs by which progressive motion is performed. In the space between the head and tunic in front, there is an opening or *funnel* with a projecting aperture. This funnel opens into the cavity of the sac, and serves to convey water to the gills, and to carry off the different excreted matters.

The brain in the cephalopoda is contained in an irregular hollow ring in the cartilaginous border of the oral disk. This cartilage is thickest on the dorsal aspect, and contains the parts which have been denominated cerebrum and cerebellum, the remaining part of the canal being occupied with the collar, which surrounds the esophagus. The nerves, which proceed directly from the brain to the parts which they are destined to influence, are few in number. From the cerebrum issue a few small nerves, which go to the mouth, and the base of the feet—others which go to form ganglia at the mouth, and others for supplying the feet. The cerebellum, besides furnishing the collar which encircles the gullet, contributes to the formation of the large ganglia which supply the arms—the optic and auditory nerves—those for the funnel, the tunic, and the viscera. From the size of the animals, the ganglia of the nerves are very distinctly displayed. The anastomosing branches of the nerves of the arms are likewise conspicuous. Each nerve at the base of each foot sends out two filaments, one to the nerve of the foot on each side. In this manner a chain of nerves is formed round the base of the feet, probably calculated to enable them to act more readily in concert.

From the abundant distribution of nerves to the different parts, it appears probable that the sense of touch exists in a tolerably perfect manner. There is no proof of the development of organs for the display of the senses of smell and taste.

The cephalopoda are furnished with two eyes, one on each side of the head. The external membrane on the inner side, which may be compared to the *sclerotica*, differs in many particulars from the covering of the same name in the eyes of the vertebral animals. While it surrounds the contents of the eye from the entrance of the optic nerve to the pupil, it is greatly separated from the choroides. Immediately within its cavity, there is a bag with a peculiar membraneous covering, which contains numerous glandular bodies, similar to the milt of fishes, by which the eye is supported, and which probably act as secreting organs, (although M. Cuvier could not detect any excretory canals,) and likewise an expansion or ganglion of the optic nerve. The concave or anterior surface embraces the *choroides*. This membrane, after embracing the vitreous humour, forms a zone or diaphragm, which may be compared to the ciliary processes, with an aperture in the centre for the reception of the crystalline lens. The circular margin of this aperture is lodged in, and intimately united with a circular groove, by which the lens is divided into two unequal hemispheres. Its central surface is coated, as in the higher classes of animals, with the coloured mucous pigment, which has been denominated *pigmentum nigrum*. In the cephalopoda, however, it is of a purplish-red colour.

The optic nerve, after entering the sclerotica, expands into a large ganglion, from the peripheral surface of which issue numerous nervous filaments. These pierce the choroides by as many holes, and go to form by their reunion the retina. This important membrane extends to the ciliary zone, and like it appears to unite itself with the groove of the lens.

The vitreous humour is contained in a peculiar vesicle, having the lens seated in a concavity on its external surface. The lens divides easily into two parts, the line of separation being the groove which receives the ciliary ligament. Each portion consists of a number of concentric layers of variable thickness, composed of radiated fibres, becoming less and less distinct towards the centre, near which the laminated and radiated appearances cease to be perceptible. An imperfect representation of this structure is given by Sir E. Home, probably from preparations by Mr. John Hunter, in the *Phil. Trans.* vol. lxxxiv. tab. 5 p. 26.

The conjunctiva supplies the place of a cornea, and covers directly the crystalline lens, as there is no aqueous humour. This membrane in some is continuous with the skin, but in others there are imperfect eye-lids, formed by its duplicature, previous to passing over the lens. The skin, at the opening of the pupil, formed by the sclerotica, in the absence of an *uvea* and *iris*, is strengthened by a membrane which appears to be muscular, and probably assists in the contraction or enlargement of the aperture.

The animals of the cephalodous class, besides containing complicated eyes, are likewise furnished with ears. These are situated in the annular cartilage which supports the arms. In this cartilage there are two cavities. In each of these there is a bag filled with a gelatinous transparent fluid, and containing a calcareous substance, differing in its consistence, according to the species, from the brittleness of starch to the hardness of bone.

The auditory nerve penetrates the walls of this labyrinth, and ramifies on the membranous bag which it contains. There is no external opening, nor any apparent alteration in the thickness of the investing integuments.

The digestive system of the Cephalopoda exhibits several appearances by which it may be distinguished. The arms which surround the mouth, seize the animals which are to serve as food, and bring them to the mouth. The mouth is situated in the centre of the disk, round which the tentacula are arranged. It is surrounded with a slight fold of the skin, which may be compared to lips, and which is rough on the central aspect. Within these are the two mandibles, of a deep brown colour, hard horny consistence, and in form resembling the beaks of a parrot. Where free, they are conico-tubular, but where covered, they are open at the central side. The under beak, unlike the same organ in birds, is the largest, the most crooked, and embraces the upper, or the one on the dorsal margin of the mouth. These jaws are merely able to open and shut, as they possess no lateral motion. They are supported by the muscular bed of the mouth, which serves as a mould to fill the cavity towards the point. The tongue is situated between the beaks, and is armed with reflected teeth. These teeth, in consequence of the undulatory motion of the substance of the tongue, expedite the progress of the food into the gullet.

The salivary glands are four in number; the first pair, seated on each side the muscular bed of the mouth, are each divided into numerous lobes, whose excretory ducts pour their fluid into the beginning of the gullet. The second pair, seated lower down and below the eyes, are not so much divided, and send out each a canal. These unite, and pour their contents into the mouth.

The gullet is furnished with a lateral expansion, not unlike the crop of gallinaceous birds. The stomach is muscular, like the gizzard of fowls, and the cuticle is thick, and separates easily from the other membranes. At the pyloric opening of the stomach, there is another aperture equally large, which leads into the *spiral stomach*, or cæcum, as it has been improperly termed by some anatomists. It may with greater propriety be denominated the duodenum, as it performs some of the offices of that part of the gut in the higher orders of animals. This stomach is conical, closed at the distal extremity, and performs about a turn and a half, like a spiral shell. Its inner surface is covered with a ridge, which traverses it in a closely spiral direction. The bile flows into it near the apex, and towards its base, glandular orifices pouring out a thick yellow fluid may be observed. The intestine, after leaving the pyloris, in some species makes one or two turns, in others it proceeds directly to the anus. This opening is seated at the base of the funnel, on its posterior or dorsal side.

The *liver* is of considerable size, of an orange-yellow colour, and of a soft and spongy texture. It gives rise to two hepatic ducts, which proceed to the extremity of the spiral stomach, where they empty the orange-coloured bile which they contain by a common orifice.

The organs of circulation consist merely of veins and arteries, which we distinguish into pulmonic and systemic. The veins, which have their origin in the feet, mouth, and annular cartilage, coalesce, and form two branches, which afterwards unite into a common trunk. This vessel, after descending through part of the viscera into the abdomen, divides into two branches, each of which may be considered as a *vena cava*, conveying the blood to the lateral hearts. Each vena cava, at its origin, is joined by an equally large vessel, which empties its contents in a direction nearly at right angles with the former. These veins arise in the stomach, intestines, liver, and organs of generation. The vena cava receives a second large vessel, nearly in the same direction as the first, which has its origin in the tunic and the supports of the branchiæ. From the size of the vena cava, in consequence of the union of these two branches, and the appearance of muscular ridges on its inner surface, it has been compared by some to an auricle.

On each side, in the common cavity of the tunic, and near the gills, an aperture may be observed, the entrance to a bag or cavity. Each cavity is traversed by the vena cava of that side, and in its passage exhibits a curious confirmation. The surface of the vein is covered with spongy glandular bodies of different shapes. These, upon being pressed, pour out an opake yellow mucous fluid. Within, these glands communicate by means of very wide ducts with the cavity of the vein. Indeed, when air is blown into the vein, it readily passes through the glands into the bag, and from thence into the cavity of the tunic; and when air is blown into the bag, it likewise penetrates the gland, and passes through into the veins. The arteries with which these glands are furnished are comparatively minute.

It appears probable that these glands separate some principle from the blood, and that this is conveyed away by the ejection of the water from these venous bags into the common cavity. Were it practicable to analyse the yellow mucus which these glands contain, some light might be thrown on this subject. Indeed, it appears not improbable that this arrangement is analogous in its functions to the urinary system in the most perfect classes.

Each vena cava enters its corresponding lateral heart or ventricle, through an intervening valve. Each lateral heart is situated at the base of each gill, is pear-shaped, black, moderately thick, with numerous pits on its inner surface. Its narrow end terminates without any valvular structure in the pulmonary artery. In the genus octopus, the lateral hearts are naked; but in the generalolego and sepia, there is suspended from each, by a slender footstalk, a spongy round body, which is concave beneath. The footstalk consists of fibres, which are attached to the surface of the heart, but there is no communication by ducts or vessels. The use of this organ is unknown.

The animals of this class continually reside in the water, and respire by means of gills or branchiæ. These are double, one on each side, corresponding with the lateral pulmonic ventricles. Each gill is connected at its opposite sides to the tunic, by means of fleshy ligamentous bands. Between these, the double leaves of the gills are arranged in an alternate series. Each leaf is supported by a footstalk from the band, and is subdivided into smaller leaves, to expose a greater surface to the water.

The pulmonary artery passes along this band, sends a branch into each footstalk, which, penetrating the substance of the gills, conveys the blood to its different divisions.

The systemic veins depart from the gills at the opposite extremity. These unite at the inferior band, and from each gill a vessel proceeds to the single central or systemic heart or ventricle. In some of the animals of this class the systemic veins are somewhat enlarged, and assume the appearance of auricles. The two pulmonary, or rather the systemic veins, enter the heart at the opposite side, each at the termination being furnished with a valvular organization.

The systemic heart is white and fleshy, and differs according to the genera in its form, being in the Octopus semicircular, but in the Loligo and Sepia lobed. Besides giving rise to a large aorta, or principal artery, two smaller ones likewise proceed from its cavity. These arteries are furnished at their entrance with valves.

The sexes in the Cephalopoda are distinct, the male and female organs being found on different individuals. There is not, however, any external mark by which they may be distinguished. M. Cuvier found that the males of the Octopus were scarcely a fifth part so numerous as the females.

The male organs of generation consist of the following parts. The *testicle* is a large white glandular purse, containing numerous fringed filaments, from which the seminal fluid is secreted. This fluid passes out of the testicle, by a valvular opening, into the *vas deferens.* This canal is slender, and greatly twisted in its course, and opens into a cavity which has been compared to the *seminal vesicle.* The walls of this last cavity are strong and muscular, and disposed in ridges. Near the opening at the distal extremity of this sac, is an aperture, leading into an oblong glandular body, regarded as exercising the functions of a *prostate gland.* Beyond this lies a muscular sac, divided at the top, where it opens by two ducts, but connected at the base. In this sac are numerous white thread-like bodies, terminated by a filament, but unconnected with the sac. In the interior they consist of a spiral body, connected at each extremity with a glandular substance. When these bodies are put into water, they twist themselves in various directions, and throw out at one of their extremities an opaque fluid. These motions are not excited by placing them in oil or spirit of wine, but they may be exhibited by immersing in water those which have been kept for years in spirits.

These bodies, first observed by Swammerdam, and afterwards by Needham, have been regarded by some as demonstrating the truth of the vermicular theory of generation; by others, they have been considered as analogous to the pollen of plants—that their tunic is in part soluble in water, and when they are thrown into that fluid, they speedily burst, and spread their impregnating contents over the eggs of the female. Although this last conjecture is plausible, and countenanced by the circumstance that these vermicular bodies are only found at the season of reproduction, the subject is still involved in obscurity. Are these bodies produced in the testicle, and only brought to this bag when nearly ready for exclusion; or, if the product of the bag itself, by what means are they nourished?

The male organs terminate in a cylindrical fleshy body termed the penis. This is hollow within, and ribbed with muscular bands. Near its base it receives one of the ducts of the vermicular sac, continuous with the one from the prostate gland, forming its canal, and toward the apex the other duct. It projects but a short way into the cavity of the great bag, into which it empties its contents. These pass out of the body at the funnel-form opening in the throat.

The female organs of generation consist of an ovarium and oviduct. The ovarium is a glandular sac, to which the ova are attached by footstalks. The opening by which they issue from the ovarium is wide, and the oviduct (in the Octopus vulgaris and Loligo sagittata,) after continuing a short way simple, divides into two branches, each having its external aperture near the anus. The oviducts are furnished within with muscular bands, and a mucous lining, and encircled with a large glandular zone, destined, probably, to secrete the integuments of the eggs. In the Loligo vulgaris, and the Sepia, the oviduct continues single. Besides these organs, the Loligo vulgaris and sagittata, and the Sepia, have two large oval glandular bodies, divided by transverse partitions, with their excretory ducts terminating at the anus, whose use is unknown.

The eggs, whose peculiar form has been already noticed, pass out of the funnel, after which they are supposed to be impregnated by the male, according to the manner of fishes.

The *inky fluid* now remains to be considered, as the most remarkable of the peculiar secretions of this tribe of animals. The organ in which this fluid is secreted is spongy and glandular. In some species it is contained in a recess of the liver, which has given rise to the opinion that the coloured fluid which it secreted was bile. In other species, however, this gland is detached from the liver, and either situated in front or beneath that organ. The excretory canal of this gland opens in the rectum, so that the fluid escapes through the funnel. It mixes readily with water, and imparts to it its own peculiar colour. When dried, it is used as a pigment, and is considered as the basis of China ink.

The Cephalopoda are all inhabitants of the sea. They are widely distributed, occurring in the arctic as well as the equatorial seas. In the latter, however, they grow to the largest size. It is reported, that in the Indian Seas, boats have been sunk by these animals affixing to them their long arms, and that they are dreaded by divers.

In the classification of the animals of this class, many difficulties present themselves, in consequence of the imperfect descriptions of their external characters, given by naturalists. In the following general view we shall endeavour to distribute them into natural groups and genera, without attempting an enumeration of all the species. Such only as are inhabitants of the British seas shall be particularly enumerated.

The Cephalopoda appear to constitute two great divisions, distinguished by the support which is afforded to the abdominal sac. In the first, which may be termed *sepiacea*, the sac is strengthened by horny or testaceous processes, unless where the habits of the animal renders such protection unnecessary. The second division, which may be termed *Nautilacea*, comprehends those animals furnished with a multilocular shell. These two divisions constituted in the Linnæan system the two genera, Sepia and Nautilus.

1. Sepiacea. Although the animals of this division agree in many external and internal characters, there are, however, considerable differences of structure to warrant their subdivision into two orders. In the first order will be included such as are furnished with only eight arms, and whose sac is destitute of fin-like expansions, and either simple, or strengthened behind in the interior by two short corneous processes. The head is united to the sac behind, without the intervention of a neck. The suckers have soft margins. The second will comprehend those which are furnished with eight arms and two feet, whose sac is furnished with fin-like expansions, and strengthened internally by corneous or testaceous ribs or plates. The head is divided from the sac on all sides by a neck. The suckers have a corneous margin.

The first order might admit of some subordinate divisions, founded on differences in the habits of the animals. It will suffice that we notice merely the genera. These are three in number, Octopus, Eledona, and Ocythöe.

1. *Octopus*. This genus, so named by Lamarck, is the Polypus of Aristotle. All the arms are of equal size, and the suckers with which they are furnished are sessile, and arranged in a double row on their central aspect. The oviduct is double, and the margin of the anus is simple.

There are several species belonging to this genus; but the one with which naturalists have been longest acquainted is the Sepia octopodia of Linnæus, or *Octopus vulgaris*, of modern arrangements. There is a figure of it in Pennant's British Zoology, vol. iv. p. 53, No. 44. Tab. xxviii. The body is short, and rounded at the tail. The arms are nearly six times the length of the body, and furnished with about two hundred and forty suckers. This species inhabits the British seas, and has been termed Poor Cuttle, Pour-contrel, and Preke. It was first recorded as a native by Merrat in his Pinare, p. 191. It is occasionally dredged up from the oyster-beds in the Frith of Forth. Baker describes a species analogous to this in the *Philosophical Transactions* for the year 1757, p. 777, Tab. xxix.

2. *Eledona*. This genus was known to Aristotle. It agrees with the preceding genus in having all the arms similar, but it is distinguished by each arm having only a single row of suckers.

Lamarck has figured and described two species of this genus in the *Mem. de la Soc. d'Hist. Nat.* One of these, a native of the Mediterranean, is remarkable for giving out an odour like musk.

3. *Ocythöe*. In this genus, so named by M. Rafinesque, there are two of the arms furnished at their inner extremities with membranaceous expansions. The suckers, which are in a double row, are supported on short footstalks. Dr. Leach observed "four oblong spots on the inside of the tube, resembling surfaces for the secretion of mucus; two inferior and lateral, and two superior, larger, and meeting anteriorly. On the rim of the sac, immediately above the branchiæ, on each side, is a small, short, fleshy tubercle, which fits into an excavation on the opposite side of the sac. This character, which, with slight modifications, is common to this genus, to Loligo and Sepia, does not exist in the Polypus." *Phil. Tr.* vol. cvii. p. 295.

The animals of this genus were for a long time considered as the fabricators of the shell termed *Argonauta*, or the Paper Nautilus, never having been found in any other condition than occupying the cavity of that shell. The clustered eggs (which they have in common with the other cephalopoda,) have likewise been found in the cavity at the top of the spire, the female occupying the mouth. They are capable of raising themselves to the surface, and of floating and moving there by means of their winged feelers, aided probably by secreted air in their body. Upon the approach of danger they sink rapidly to the bottom.

Although this animal has never been found but in the cavity of the shell of an Argonauta, there are various circumstances which confirm us in the belief, that it is not the fabricator of the shell, but, like the Hermit crab, occupies the deserted dwelling of another animal, which has not as yet fallen under the observation of naturalists. The body of the animal does not conform in shape to the cavity of the shell, nor to all its irregularities of surface. There is no muscular or ligamentous attachment between the animal and the shell, so that it is able to leave the shell at pleasure, as it was observed to do by the late Mr. Cranch, zoologist to the Congo expedition. The reader who is desirous of farther information on this subject, may consult Dr. Leach's *Observations on the Genus Ocythöe of Rafinesque;* and Sir E. Home on the *Distinguishing characters between the ova of the Sepia and those of the vermes testacea that live in water;* in the *Philosophical Transactions for the year* 1817, art. xxii. xxiii.; and a paper by Mr. Say *On the Genus Ocythöe* in the *Phil. Trans.* 1819, art. vii.

The genera which belong to the *second* order are only two in number, viz. Sepia and Loligo. In both, the suckers on the arms are pedunculated, and their margin strengthened by a corneous ring furnished with teeth, and the margin of the anus is surrounded with appendages or tentacula. The two feet with which the animals of this order are furnished are nearly similar in their structure to the arms, but considerably larger in their dimensions. They take their rise on the ventral side of the mouth, between that organ and the funnel.

4. *Sepia*. In this restricted genus the sac is furnished on each side throughout its whole length with a narrow fin, and strengthened on the back by a complicated calcareous plate, lodged in a peculiar cavity. The suckers are irregularly scattered on the arms and feet.

The calcareous plate has been long known under the name of *cuttle-fish bone*. It is somewhat ovate, flatly convex on both sides, and thickest where broadest. The superior half, or the one next the head, is the longest, rounded at the extremity, and thin. The inferior portion becomes suddenly narrow, and ends in a point. It may be considered as consisting of a dermal plate, concave on the central aspect, having its concavity filled up with layers which are convex on their central aspect.

According to our observations the dermal plate appears to consist of three different laminæ, arranged parallel to one another. The external or dorsal layer is rough on the surface, and marked by obscure concentric arches towards the summit, formed by minute knobs, which become larger towards the base, where they appear in the form of interrupted transverse ridges. It is uniform in its structure, and the tubercles possess a polish and hardness equal to porcellaneous shells, although they blacken speedily when put in the fire, and contain a good deal of animal matter. On the central side of this layer is one flexible and transparent, similar to horn, and smooth on the surface. The third layer is destitute of lustre, and in hardness and structure resembles mother of pearl shells.

The layers which fill the concavity of this dermal plate are slightly convex on the central aspect, and are in part imbricated. Each layer is attached to the concave surface of the dermal plate by the upper extremity and the two sides, while the inferior or caudal extremity is free. The inferior and first formed layers are short, and occupy the base and middle, and rise from the plate under a more obtuse angle than the new formed layers, which are both the longest and the broadest.

Each layer, which is about one-fiftieth of an inch in diameter, consists of a very thin plate, whose dermal surface, when viewed with a magnifier, exhibits numerous brain-like gyrations. From the ventral surface of this plate arise numerous perpendicular laminæ, which, when viewed laterally, appear like fine parallel threads, but, when examined vertically, are found to be waved, and fold upon themselves. Next the plate they are thin, and not much folded; but towards their other extremity, they become thicker, striated across, and more folded, with irregular margins. On the thick tortuous even ends of these laminæ, the succeeding plate rests, and derives from them the peculiar markings of its surface. These laminæ are closely set, irregularly interrupted, and occasionally anastomose. M. Cuvier (*Mem. sur la Seiche*, p. 47.) states, erroneously, that these laminæ are hollow pillars disposed in a quincunx order.

The term bone has been improperly applied to this complicated plate; "for," (according to Mr. Hatchett, *Phil. Trans.* vol. lxxxix. p. 321.) "this substance, in composition, is exactly similar to shell, and consists of various membranes hardened by carbonate of lime, without the smallest mixture of phosphate."

This bone was formerly much prized in medicine as an absorbent, but is now chiefly sought after for the purpose of polishing the softer metals.

The most remarkable species of this genus is the *Sepia officinalis*, which is distinguished from the others by its smooth skin. It inhabits the British seas, and, although seldom taken, its bone is cast ashore on different parts of the coast, from the south of England to the Zetland isles.

5. *Loligo*, or Calamary. This genus, the larger species of which are known to the fishermen under the denominations Sleeve-fish, Hose-fish, and Anchor-fish, is distinguished from the former by having the sides of the sac furnished only partially with fins. The dorsal plate is flexible and corneous, imbedded in the substance of the sac, and is multiplied with years. The suckers are disposed on the arms and feet in a double row.

The species of this genus have not been investigated with much care. Four sorts have been found in our seas, which are probably the types of as many different genera. In two of these the sac is cylindrical above, and compressed towards the tail, with which the fins on each side are united.

In the *Loligo vulgaris*, the fins, together with the tail, form a rhomboidal expansion. The feet are nearly of the same length with the body, and covered with suckers only near their distal extremity. There is no eye-lid. The bone is elliptical, elongated, and produced at the upper extremity, with a groove along the middle. The appendage to the stomach is straight, and the oviduct is single.

This species is described and figured by Borlace, in his *Natural History of Cornwall*, p. 260. Tab. xxv. f. 27; and by Pennant in the *British Zoology*, vol. iv. p. 53. No. 43. Tab. xxvii.

In the *Loligo sagittata*, the fins, with the tail, form a triangular expansion; the feet are shorter than the body, and covered with suckers nearly to their base. There is a duplicature of the skin round the eye, forming an eye-lid. The bone is narrow, thin, expanded at both ends, and strengthened by two marginal ribs, and one in the centre. The appendage to the stomach is spiral, and the oviduct double.

This species has hitherto, in this country, been confounded with the preceding. It is, however, the one alluded to by Monro, secundus, in his *Structure and Physiology of Fishes*, p. 62. tab. xli. xlii. His specimens were probably obtained from the Frith of Forth. The same species has occurred to the writer of this article in the Frith of Tay.

In the two remaining species the fins which occur near the tail are not continued to its extremity. The *Loligo media* has the sac long, slender, and rounded. The fins on each side are of an elliptical form, and the tail is produced beneath into a point. This appears to be a rare species. It is figured by Pennant in his *British Zoology*, vol. 4, tab. xxix. No. 45.

In the *Loligo sepiola*, the body is nearly of equal dimensions in length and breadth; the fins are thin and rounded, and the outline of the tail semicircular. It is figured by Pennant in the *British Zoology*, vol. 4. tab. xxix. No. 46. This species appears to be rare. It is recorded by Pennant as having been taken off Flintshire. A specimen now before us was obtained in the Frith of Forth, at Kirkaldy, by Mr. Chalmers, surgeon of that town.

Various species of the Sepiacea were formerly used as food; and Aristotle informs us that they were considered in the best condition for the table when nearly ready for spawning. The modern Italians and Greeks are said to use them still as an article of diet, and to consider the eggs as a great delicacy. In our own country, Mouffet considered them excellent meat, when boiled with wine and spices.

The animals of the second great division of the cephalopoda may be considered as nearly unknown. The shells were united by Linnæus in one genus, which he termed Nautilus; but, in consequence of their peculiar characters, they have been sub-divided into many new genera. The animals belonging to two of these modern genera, spirula and nautilus, which both belong to the spiral multilocular tribe, have been imperfectly described.

The *shell* of the *Spirula* has the whorls separate, the mouth orbicular, the chambers perforated by a tube, and the last cell produced into a tube. The *animal* resembles the Sepia, and the shell is concealed under the skin, and occupies a similar situation to the cuttle-bone.

The animal of the *Spirula vulgaris* appears to be very common in the West Indies, as the chambered spiral extremity of the shell is frequently brought to this country.

In the *shell* of the restricted genus *Nautilus*, the turns of the spire are contiguous, the last whorl embraces the others on the sides, and the chambers are perforated by a tube. The animal of the *Nautilus pompilius*, according to Rumphius, lodges in the last chambers, and is fixed by a ligament which descends into the tube. The arms which surround the mouth are destitute of suckers.

Among the minute shells which occur in the roots of sea-weeds, on old shells, corals, and sertulariæ, are many genera of multilocular testacea, some of which have been described in the article Conchology. Guided by analogy, naturalists have been disposed to consider these as the productions of cephalopodous mollusca. Their inhabitants, however, have not been examined, and the task of doing so will be very difficult, as they are all very minute. When it is considered that a gasteropodous mollusca breathing air, Segmentina (Nautilus of Lightfoot) palustris, has its shell divided into chambers by transverse partitions, and that the shells of some of the Annelides likewise exhibit appearances of being multilocular, the analogy loses its value, and we are disposed to conclude that the true place in the systematical arrangement of animals, for the introduction of these minute shells, remains to be ascertained. Indeed, until the animals of the Spirula and Nautilus shall have undergone a more minute investigation, the characters by which they are distinguished must be viewed with suspicion.

Many species of multilocular testacea occur in a fossil state, which are usually considered as the remains of cephalopodous mollusca. Some of these are spiral like the Nautilus, others are orbicular like the Miliola, while in a third the chambered shell is nearly straight, as in the Orthocera.

As intimately related to the last mentioned genus, we may here take notice of the *belemnite*. In this fossil the apex is solid, with a groove or fold on one side, and at the thick end there is a conical cavity filled with a shell divided into chambers, which are penetrated by a pipe. If we regard this body as the remains of a cephalopodous animal, we may consider the exterior solid extremity to have been a corneous covering, and the chambered alveolus as the seat of the body of the animal, which likewise enveloped the base. That the solid base was hard, and not muscular, like the sac of the Sepiacea, is obvious from the surpulæ which have been found adhering to its surface, and which probably took up their residence after the death of the animal, and the destruction of the soft covering. That the solid part was different in its nature from shell, appears probable from the circumstance that the latter, when mineralized, is usually converted into calcareous spar, while the former appears of a fibrous structure.

The alveoli of the belemnite bear so near a resemblance to the species of Orthocera, that some have concluded that the latter were originally parts of a belemnite. Several circumstances, however, militate against this opinion. Orthoceratites are frequently found fossil where there are no vestiges of belemnites, and even appear to occur in older rocks. Many recent species of the genus Orthocera have been found on our own shores without the vestige of an external covering. Had they possessed any such solid apex, like the belemnite, it is probable that it would have been detected in the recent kinds, since it is sufficiently durable to retain its form in the solid strata. The shell of the belemnite was probably, in some respects, internal—that of the orthocera was probably external, or covered only by the common integuments. The views here given do not greatly differ from those of Mr. Plat, in the *Philosophical Transactions*, vol. liv. p. 38.

Class II.—PTEROPODA.

This class was instituted by Cuvier, for the reception of a few genera, whose peculiar characters indicated the impropriety of suffering them to remain in any of those categories which had been previously established. All the species are small in size, and the attempts which have been hitherto made to investigate their internal structure have, in a great measure, failed in explaining the functions of the organs which are exhibited. The valuable papers of Cuvier, on the Clio, Pneumodermon, and Hyalea, include nearly all the accurate information on the subject of which naturalists are in possession.

The general form of these animals is somewhat ovate. The tunic appears in some genera, as the Clio and Pneumodermon, to be double, the external one soft and thin, the internal exhibiting a fibrous structure, corresponding to the muscular web of the skin of the higher classes. In these animals, however, these two layers are unconnected throughout the greater part of their expansion. In some, as the cymbulia, the tunic is cartilaginous, while in others it is strengthened by a shell. In these last, the shell in the Limacina is a spiral univalve, covering the abdominal viscera, and in the Hyalea, where it serves the same purpose, it approaches in character a bivalve shell. It is, however, destitute of a hinge, the two valves being united together at their caudal margins, and there is no appearance of a transverse adductor muscle.

The organs of motion in all the genera consist of two fins, or membranaceous expansions, seated one on each side the head. They have no foot wherewith to crawl, nor any suckers by which they can adhere to objects. They are therefore free animals, moving about in the water by means of their fins, and possessing, probably at the same time, a power of varying their specific gravity, as they are capable of varying, to a certain extent, the form of their bodies, and of enlarging or reducing their dimensions. There is nothing peculiar in their nervous system.

Their organs of digestion differ greatly from those of the cephalopoda, which we have already considered. They are generally regarded as destitute of eyes and ears. Their tentacula are either seated on the head, forming two complicated branches of filaments, or spread along the margin of the tunic. There are no arms for seizing the food. The mouth, however, is furnished with lips, and, in some, an appearance of a tongue at the entrance of the gullet. The salivary glands are two in number, lengthened, descending a considerable way into the abdomen, and pouring their contents, by means of their excretory canals, into the cavity of the mouth. The gullet, after being encircled by the nervous collar, suffers an enlargement, which has been termed a crop, contiguous to which is the stomach. Both these cavities exhibit muscular ridges on the inner surface. The liver surrounds the stomach, and is intimately united with its contents, and pours in its bile by numerous pores. The intestine is short, and after making one or two turns, ascends and terminates in the neck near the mouth.

The circulating system in this class has been but very imperfectly investigated. The pulmonic vessels are unknown, but systemic veins, a single auricle, ventricle, and aorta, have been detected. The heart, in some, is situated on the left, in others on the right side of the body.

The respiratory or aërating organs, exhibit very remarkable differences. In the Clio they are in the form of a fine net work on the surface of the fins; in the Pneumodermon they are conjectured to form leaf-like ridges on the caudal extremity of the body, or if these ridges are to be considered as particular kinds of fins, the gills may be sought for on the membranaceous expansions of the neck. In the Hyalea the branchiæ form a complex band on each side the body, at the lateral opening of the shell.

The animals of this class are all hermaphrodites. There is a common cavity, a vesicle, penis, vas deferens, and testicle, together with an oviduct and ovarium. These open near the mouth on its ventral margin. There is nothing known with respect to the appearance of the eggs, the period of propagating, or the form of their young.

All the animals of this class inhabit the sea. Some of those, as the Clio and Limacina, frequent the arctic regions, and afford the whale a great part of its sustenance. None of the species of the class have hitherto been detected in the British seas.

M. Cuvier, in his *Règne Animal*, II. p. 378, subdivides the genera of this class into two orders. The animals included in the first are furnished with a head distinct from the body, and are arranged under the five following genera; Clio, Cleodora, Cymbulia, Limacina, and Pneumodermon. Those of the second division, which are destitute of a head, constitute only one genus, named Hyalea.

1. *Clio.*—In this genus the body is ovate and elongated, the tunic membranaceous, and the head divided into two lobes, whose summits are furnished with tentacula. The mouth is transverse, with two lateral longitudinal lips. On each side the neck arise two blunt, conical, fin-like expansions, with a fine reticulated surface, considered as serving the double purpose of fins and branchiæ. The anus and orifice of generation terminate under the base of the right branchia. The viscera do not fill entirely the cavity of the inner bag. The gut makes only one fold. The existence of eyes has not been ascertained.

The genus Clio was originally instituted by Brown, in his *Natural History of Jamaica*. It was afterwards embraced and modified by Linnæus and Pallas, in such a manner as ultimately to exclude the species for whose reception Brown originally formed it. It contains two species, the most remarkable of which is the *Clio borealis*. Mr. Scoresby, in his valuable work on the Arctic Regions, lately published, states (vol. i. p. 544.) that it occurs in vast numbers in some situations near Spitzbergen, but is not found generally throughout the arctic seas. In swimming, it brings the tips of the fins almost into contact, first on one side, and then on the other.

2. *Cleodora.*—This genus was instituted by Peron, for the reception of Brown's species of Clio. The body is covered with a triangular pyramidal tunic, carrying two membranaceous wings, between which is the mouth, furnished with a semicircular lip.

The species whose characters have been most fully developed, is the Cleodora pyramidata. *Brown's Jamaica*, p. 386. tab. 43. fig. 1.

3. *Cymbulia.*—The tunic of the species of this genus is trough-shaped, and cartilaginous. The fin-like expansion is single, divided into three lobes, one of which is small, with two tubercles, and a minute fleshy beard. This genus was instituted by Peron, in *Annales du Museum*, vol. xv. tab. 3. fig. 10, 11.

4. *Limacina.*—This genus is nearly allied to Clio, in the form of the head and wings, but the body of the animal is contained in a tender shell of one turn and a half, flat on one side, with a large umbilicus in the other. When the animal swims, the head and fin-like expansions are protruded from the shell.

This genus was instituted by Cuvier, for the reception of the Clio helicina, an animal first described by Captain Phipps, and afterwards by Fabricius, under the name of Argonauta artica. According to Mr. Scoresby, it is found in immense quantities near the coast of Spitzbergen, but does not occur out of sight of land.

5. *Pneumodermon.*—The body, in the species of this genus, is oval. The neck is narrow, with a fin-like expansion on each side. The mouth is nearly terminal, furnished on each side with a fleshy lip, and below with a fleshy chin. On the summit are two bundles of tentacula, each consisting of a filament, with a tubercle at the end, pierced by a small hole, and considered as exercising the office of a sucker. Cuvier, in his *Memoire sur L'Hayle et le Pneumoderme*, considered the leaf-like ridges which occur on the caudal extremity of the body as the branchiæ, and even describes the pulmonary vein which conveys the blood from these to the heart. But, in his *Regne Animal*, he states it as the opinion of his assistant, M. Blainville, that the fin-like expansions of the neck contain the branchiæ on their surface, as in the case of Clio. The rectum and oviduct terminate under the right wing. Cuvier has figured and described the only known species, which he terms *Pneumodermon Peronii*, the trivial name being in honour of the discoverer, M. Peron.

6. *Hyalea.*—The animals of this genus, as we have already stated, are destitute of a head. The body is lodged between two plates or valves, united at the base, where they inclose the caudal extremity. The ventral valve is nearly flat, with an uneven margin, narrow anteriorly, but expanding behind, and terminating in three projecting points. From the middle point four ribs diverge forward, and a muscle arises, which, fixed in the superior viscera, enables the animal to withdraw into the shell. The dorsal valve is shorter than the preceding, the margin flat and circular, and the middle convex outwardly. In the space between the lateral margin of the two valves, on each side, the branchiæ are situated, in a duplicature of the tunic, the sides of which are furnished with filaments. The fleshy neck supports the two membranaceous expansions; between which and the base the mouth is situated, surrounded by two lips, and strengthened within by two fleshy cheeks. The opening of the anus and oviduct are at the base of the right fin.

The Hyalea tridentata, the best known species of the genus, was first noticed by Forskal, in his *Descriptiones Animalium*, p. 124, as an Anomia, and inhabiting the Mediterranean.

Class III.—GASTEROPODA.

The animals which are included in this class are more numerous in regard to species, and exhibit a greater diversity of organization, than those belonging to the other great divisions of molluscous animals. They have long occupied the attention of the zoologist, and various methods have been proposed for their artificial and natural arrangement. Their internal structure has likewise been investigated with a considerable degree of success, and the purposes which the different organs serve in the animal economy, have been in a great measure ascertained.

The Gasteropoda present few characters which are common to the whole class. Their body may be regarded as consisting of a foot, the cloak or tunic, and the head. The *foot* is a firm muscular expansion, covering a part or the whole of the ventral surface of the animal. The viscera and head rests on its central surface, while externally it exhibits a soft even disk, capable of acting as a sucker, with which the animal adheres to objects when at rest, and by which it crawls from one place to another. It is likewise used as a fin in swimming, being aided at the same time by the serpentine motion of the whole body. The tunic arises on each side of the foot, and forms an arch over it for the reception of the viscera. Behind, the sac thus formed is closed, whose front is occupied by the neck and head. The tunic on the back is, in some cases, fortified by one or more testaceous plates; in others it is protected by a conical or spiral shell.

The *head* is connected at the sides and on the back with the cloak, and beneath with the foot. In general it is furnished with tentacula as organs of touch.

The organs of circulation are more simple than in the cephalopoda. There is no pulmonic auricle nor ventricle, the veins which correspond with the vena cava in the higher classes proceeding directly to the lungs or branchiæ. There is, however, a systemic auricle, which receives the aërated blood, and a systemic ventricle, which transmits it to the different parts of the body. The heart is usually situated on the left side; but in those genera furnished with a spiral shell, it is always on the side next the pillar, or the one opposite to that to which the spire of the shell is directed.

The organs of respiration exhibit the two modifications of lungs and gills. The lungs, destined to respire free air, are usually seated in a cavity on one side, whose orifice is capable of being closed at the will of the animal. The walls of this cavity are lined with a delicate net-work of vessels, in which the blood is exposed to the decarbonizing influence of the atmosphere. In those animals whose blood is aërated in water, the gills exhibit every variety of form. In some they occur in a cavity, or exposed in the form of pectinated ridges, in others assuming the appearance of shrubs. In all cases these organs are well protected, delicate in structure, and exceedingly sensible to any external impression.

These two conditions in the organs of respiration point out the propriety of forming the Gasteropoda into two subdivisions, which may be termed, according as they respire by means of lungs or gills, *Pulmonifera* and *Branchifera*. Cuvier appears to have been in some measure aware of the importance of the distinction, when he instituted his order *Pulmonés*. But he afterwards suffered himself to be more influenced by the presence of an operculum, the shape of the aperture of the shell, and the supposed separation of the sexes, than by the characters of the respiratory organs. Hence he inserted the pulmoniferous genus Cyclostoma among those which are furnished with gills.

Subdivision I.—Gasteropoda Pulmonifera.

The distinguishing character of this group of Gasteropodous mollusca, is to respire free air. This is performed in a pulmonary cavity situated at the side, the entrance to which the animal is capable of closing at pleasure. The blood-vessels are spread upon the walls of this cavity, chiefly on the roof, in the form of a delicate net-work. The opening of the cavity is usually on the right side, with the anus behind it, and the sexual orifice is in the front near the head. In some of the genera these openings are situated on the left side. The shells of the former are denominated dextral—of the latter sinistral. This change in the position of the external openings is accompanied by corresponding alteration in the arrangement of the internal organs. The heart, for example, is always placed on the side opposite the pulmonary cavity. In the dextral shells, therefore, it is sinistral, while in the sinistral shells it is dextral. In both kinds, however, all the organs preserve the same relation to the back and belly, the head and tail. It is impossible, therefore, to conceive a dextral animal changed into a sinistral, by any circumstance which could take place at the period of hatching, as M. Bosc was inclined to believe. This arrangement of the organs must have been not merely congenital, but coeval with the formation of the embryo. In some species all the individuals are sinistral, while in others the occurrence is rarely met with in a solitary example. The former are in their natural state, the latter ought to be regarded as monsters. Where the character is permanent, it should constitute a generical difference.

The animals of this subdivision have, in general, the sexual organs united in the same individual, requiring, however, mutual union. They are all oviparous.

Section I.

This is intended to include all those pulmoniferous gasteropoda which are *terrestrial*. These reside constantly on the land where they have been hatched, and where they collect their food and propagate their kind. They admit of division into two tribes, from the circumstance, that in some the shell, which is either flat, or open and subspiral, is concealed in a thickened plate of the cloak, termed the *shield*, while in others the shell is spiral or conical, external, and contains the body of the animal.

Tribe I.—The genera included in this tribe are three in number. They all possess four tentacula, capable of being withdrawn into themselves like the fingers of a glove. The eyes are black points, seated at the tips of the superior tentacula.

I. Limax. *Slug*.—The body is lengthened, and somewhat pointed behind. The cloak is corrugated, and supports the shield on the forepart of the back towards the head, containing a thin corneous or testaceous plate. The pulmonary cavity opens on the right side, at the inferior margin of the shield. Behind this opening is the anus. The sexual opening is underneath the superior tentaculum, on the right side. At the termination of the body, above, is an opening, out of which a thick glutinous fluid oozes. The surface of the whole body is liberally supplied with a glutinous secretion of the same sort, but thinner in its consistence. This fluid issues from the pores of the skin and the pulmonary cavity, and when the animal is placed before the fire, it is given out in considerable quantities. The respectable editors of the *Journal d'Histoire Naturelle*, vol. i. p. 477, recommended a lute made of this fluid, reduced to a proper consistence by quicklime, for the purpose of securing the mouths of the bottles containing anatomical preparations, and preventing the evaporation of the alcohol. With this cutaneous secretion some of the species are capable of forming a thread, by which they are able to suspend themselves from the branches of trees. This mode of assisting locomotion is recorded by Lister, (*Animalium Angliæ*, p. 130.) and subsequently noticed by other observers. *Linn. Trans.* vol. i. p. 182; and vol. iv. p. 85.

The mouth consists of lips, which are capable of small extension, and above, the entrance is armed with a concave corneous jaw, with a notch in the middle. The tongue is merely armed with soft transverse ridges, pointed before, and terminated by a short cartilaginous cone. There is a sensible dilatation of the gullet, which marks the place of the stomach, at the under extremity of which is the rudiment of a cæcum at the pyloric opening. The intestine makes several folds, chiefly in the liver, before it reaches the anus. The salivary glands reach to the extremity of the gullet. The liver is divided into five lobes, which gives rise to two ducts that open into the pylorus.

The circulating system consists of two venæ cavæ, which give out numerous branches to the pulmonary cavity. The aërated blood is conveyed by several ducts to a simple membranaceous systemic auricle. Between the auricle and ventricle there are are two valves. The ventricle is more muscular than the auricle. The arteries, which take their rise from a single aorta, are characterised by a peculiar opacity and whiteness of colour, as if they were filled with milk.

The organ of viscosity nearly encircles the pericardium. It consists of regularly pictinated plates. Its excretory canal terminates at the pulmonary cavity.

The organs of generation consist, in the female parts, of an ovarium, oviduct, and uterus; and in the male, of a testicle, vas deferens, and penis, together with the pedunculated vesicle; and, as common to both the sexual organs, there is a cavity opening externally, in which, by separate orifices, the uterus, penis, and vesicle terminate.

The species of this genus have hitherto been chiefly characterised by the shape and colours of the body; the latter, however, is liable to such great variation, that it is difficult to determine the number of species which are natives of Britain. The structure of the shield, and the relative position of the pulmonary cavity, joined with the markings of the body, ought to be resorted to; and could a knowledge of the internal structure be likewise obtained, we might then hope to be able to bestow on the species permanent marks of distinction.

Although the terrestrial gasteropoda may be considered as phytivorous, it is now known that the larger species of this genus likewise feed on the common earthworm, as has been observed by Mr. Power, (*Linn. Trans.* vol. ix. p. 323.) None of these species are used in this country as food.

II. Parmacella.—The animals of this genus are distinguished by the position of the shield, which is placed on the back, near the middle of the body, and contains, at its caudal extremity, an open subspiral testaceous plate. Underneath the shield is the pulmonary cavity.

The only species of this genus yet known was found by M. Olivier in Mesopotamia. The genus was instituted by M. Cuvier, and the species denominated P. olivieri. Along the back, from the shield to the head, are three grooves; the medial one is double. From the dissections of Cuvier, it appears that the internal structure of this species bears a close resemblance to that of the slugs. The most remarkable difference is in the two conical appendages of the common sexual cavity, by which they approach the Helices.

III. Testacella.—The shield in this genus is placed on the posterior extremity of the body, and consequently the anus and pulmonary cavity are nearly terminal. These are protected by an open subspiral testaceous plate. The foot extends on each side beyond the body. From the manner in which the blood is aërated, the auricle and ventricle are placed longitudinally, the latter being anterior.

The T. haleotoidea, described and figured in the *Histoire Naturelle des Mollusques Terrestres et Fluviatiles de la France*, par M. Draparnaud, p. 121. tab. xi. figs. 12—14, is the only species which has been distinctly ascertained. It lives in the soil, and pursues and feeds on the common earth-worm.

Tribe II.—The animals of this tribe were formerly included in the genera Helix and Turbo of Linnæus. The shells are spiral, and more or less turbinated. They are covered with a cuticle, which, in some cases, appears in the form of ridges or hairs. The following genera have been established:

1. Helix. *Snail.*—In this genus the animals have four tentacula, as in the Limax, with eyes at the tips of the superior ones. The aperture of the shell, which is somewhat lunulated, is as wide as it is long.

The internal structure of the snails very nearly resembles that of the slugs. The shield, however, has a thickened margin in front, by which the shell is formed, and the centre of the shield is as it were ruptured, giving vent to the liver and organs of generation. These occupy the cavity of the shell towards its tip, and the mouth is filled with the foot, body, and head. The animal is attached to the pillar of the shell by a complicated muscle, which shifts its place with the growth of the animal. The mouth is furnished above with a thin arched corneous mandible, notched on the edges.

The circumstances in which the snails differ from the slugs, are chiefly observable in the organs of generation. The vagina, previous to entering the common sexual cavity, is joined by the canal of the vesicle, and by two canals, each proceeding from a bundle of multifid vesicles. Each bundle consists of a stem, which is the canal, and numerous branches with blunt terminations. These canals pour forth a thin milky fluid, whose use is unknown.

Connected with the sexual cavity is the bag in which the darts are produced. The bag itself is muscular, with longitudinal grooves, and a glandular body at the extremity. This glandular body secretes the dart.

which is in the form of a lengthened pyramid, consisting of calcareous filaments nearly resembling asbestus. Previous to the sexual union, the two snails touch each other repeatedly with the mouth and tentacula, and at last the dart of the one is pushed forth by its muscular bag, and directed against the body of the other, into which it enters, never penetrating through the integuments, and even in many cases falling short of its mark. Whether the use of the dart is merely to stimulate, or whether it is subservient to any other purpose, can scarcely be said to be determined.

The species of this genus are numerous, and may admit of distribution into several sections, from circumstances connected with the form of the shell. Without instituting these at present, we shall subjoin a list of the species indigenous to Britain, which belong to this restricted genus :—1. H. Pomatia ; 2. virgata ; 3. cingenda ; 4. rufescens ; 5. cantiana ; 6. hispida ; 7. lucida ; 8. trochiformis ; 9. spinulosa ; 10. caperata ; 11. radiata ; 12. umbilicata ; 13. lapicida ; 14. albella (of Draparnaud,) found near St. Andrew's by Mrs. Fleming, Flisk ; 15. ericetorum ; 16. paludosa ; 17. crystallina (of Draparnaud,) found at Battersea by Dr. Leach ; 18. aspersa ; 19. memoralis ; 20. arbustorum ; 21. fusca ; 22. elegans (of Draparnaud,) the Trochus terristris of British writers.

The *Scarabes* of Montfort is formed from the Helix scarabæus of Linnæus.

II. Bulimus.—The shell furnishes the distinguishing mark in this family. It is turreted, and the mouth is longer than it is broad. The following species are indigenous : 1. lubricus ; 2. obscurus ; 3. lackhamensis ; 4. fasciatus.

The species which are related to the Turbo *bidens perversus* and *muscorum* of Linnæus, constitute a very natural family, which may be termed Pupacea, distinguished by the mouth being in general furnished with teeth, or testaceous laminæ, and the last whorl nearly the same or less than the preceding. Perhaps the most convenient way of dividing them is into two sections, the first including the dextral, and the second the sinistral shells.

The dextral pupacea form three genera. The Pupa, as originally constructed by Lamarck, was equally faulty with many of the old Linnæan genera. As we have restricted it to include dextral shells, with the animal possessing four tentacula, with eyes at the tips of the two longest, we can receive into it the *muscorum*, *sexdentatus*, and *juniperi*, of Montagu. The genus Chondrus of Cuvier contains the tridens of Montagu. In the genus Carychium, formed by Muller, the tentacula are only two in number, with the eyes placed at the base. It is represented by the T. *carychium* of Montagu.

The sinistral pupacea form two genera. The first, which is the Clausilia of Draparnaud, contains sinistral shells, with the animal furnished with four tentacula, with eyes at the tips of the two longest. To the pillar there is attached internally a twisted plate. This contains the following British species,—*perversa*, *nigricans laminata biblicata*, and *labiata*. The other genus, called Vertigo, was formed by Muller. The animal possesses only two tentacula, with the eyes on their tips. The T. *vertigo* is the type of the genus.

In the shells of the preceding genera, the margin of the mouth is always thick, and strengthened by a ring when the animal is arrived at full growth, after which the shell is stationary in point of size. This is a character peculiar to the terrestrial testacea. In the two genera which follow, the margin of the mouth is simple.

VIII. Vitrina.—This genus was formed by M. Daudebard de Ferussac, and termed by him Helico-limax. Draparnaud, to avoid the use of a hybrid name, substituted Vitrina. The shell is incapable of containing the animal. The margin of the shield is double, and the upper fold is divided into several lobes, which are reflected on the surface of the shell. The Helix pellucida of Muller is the type of the genus.

IX. Succinea. From the Helix succinea of Muller (the putris of Montagu and Donovan, not of Linnæus) Draparnaud has formed the genus Succinea. The mouth is large in proportion to the size of the shell, and effuse at the base, with the outer lip thin, and the pillar attenuated. We are at a loss to account for the conduct of Lamarck in substituting a new name for this genus without any apparent reason, and thus adding to the synonimes with which the science is already oppressed. The name first employed by Draparnaud, indicates one of the most striking characters of the type of the genus, whereas the term Amphibulina, used by Lamarck, is founded on a mistake, and is apt to mislead. The Helix succinea, although found in damp places, is not amphibious. It never enters the water voluntarily. Indeed, Muller says, " Sponte in aquam descendere nunquam vidi, e contra quoties eum aquæ immisi, confestim egrediebatur." The same remark is made by Montagu, and we have often witnessed its truth.

X. Achatina.—The mouth of the shell in this genus nearly resembles the Bulimi, but the end of the pillar is truncated. The Buccinum acicula of Muller, a native of England, belongs to this genus, and likewise the Helix octona of Linnæus, erroneously considered as a native of Britain.

XI. Cyclostoma. This genus is readily distinguished from all the preceding by the circular aperture of the shell, and the foot of the animal being furnished with a lid or operculum. This genus may be regarded as the type of a singular tribe of the terrestrial pulmonifera. The pulmonary cavity opens upon the neck, as in many of the pectinibranchia. The sexes are likewise separate, the penis of the male being large and muscular, but contained in the interior. The primary tentacula have sub-globular highly polished extremities, which Montagu (*Testacea Britannica*, p. 345.) is disposed to regard as eyes. The true eyes are placed at the base of the tentacula on the outside, and are elevated on tubercles, the rudiments of the second pair. The tentacula, though somewhat contractile, are incapable of being withdrawn, after the manner of the slugs and snails. The C. elegans, the Turbo elegans, of Montagu, is the type of the genus.

Sect. II.

The aquatic pulmoniferous gasteropoda, which are included in this section, have all two tentacula, usually flattened with the eyes at the internal base. The sexes are united. The spawn in the form of a gelatinous mass is deposited on aquatic plants, under water. The food consists of aquatic plants. Although they reside in the water, they are obliged to come to the surface to respire, when they open the pulmonary cavity, and, after remaining a short time, again close it and descend. Like the genera of the preceding section, they admit of distribution into two tribes.

Tribe 1.—This contains those animals which are naked, and which have been included in the genus *Onchidium*. In this genus, the animals are furnished with a cloak of more than ordinary thickness, which covers the whole of the upper part of the body. There are two long tentacula on the head, capable of being withdrawn like those of the slug. The snout is divided into two broad appendages. Between the tentacula, towards the right side, is the opening for the penis. The anus is terminal, above which is the entrance to the pulmonary cavity, and on the right is the opening to the female organs, from which a groove runs towards the right lobe of the snout.

The mouth is destitute of proboscis or jaws. The tongue is merely a cartilaginous plate, grooved transversely. The gullet is long in proportion, with a villous surface. There are three stomachs, each distinguished by its peculiar characters. The first is a true gizzard, covered internally with a cartilaginous cuticle, and its walls formed of two strong muscles with connecting ligaments. The second stomach is funnel-shaped, with prominent ridges, both on its external and internal surface. These ridges at their origin, internally, are highest, and project considerably into the cavity, acting like a valve in retarding the progress of the food. The third stomach is short and cylindrical, covered internally with equal longitudinal fine ridges. The intestine is nearly of equal thickness throughout, and about two and a half times longer than the body. The salivary glands are much branched, and pour their contents into the entrance of the gullet. The liver in the animals of this genus is distributed into three separate portions, each of which may be regarded as a distinct liver, an arrangement which is not known to take place in any other animal. The first liver is situated near the middle of the body on the right side, while the second is situated near the posterior extremity. The ducts enter the cardiac opening of the stomach, each by a separate hole, and seem to occupy the place of the zone of gastric glands observed in birds. The third liver is placed at the posterior end of the gizzard, into which it pours its contents by a short duct.

The most remarkable feature of the circulating system, is the position of the lungs, at the posterior extremity of the body, which occasions a corresponding arrangement in the connecting organs. The entrance to the pulmonary cavity is immediately above the anus. The vessels in which the blood is aerated are distributed on the roof and sides of the cavity. The pulmonic veins consist of two receptacles, one on each side, extending nearly the length of the body, which may be considered as venæ cavæ. These receive the blood by numerous vessels, and convey it directly to the lungs. The aërated blood is conveyed by a systemic vein into a large auricle, seated in front of the lungs, of considerable size, with the walls fortified on the interior by branched ligaments. The ventricle is placed at its anterior extremity, and separated by two valves. The aorta arises from the opposite side of the ventricle, its main trunk passing on towards the head.

The male and female organs of generation, although occurring in the same individual, appear to occupy different parts of the body. The opening of the male organs is at the tentacula, which leads to a cavity terminating in two unequal recesses. The anterior is the smallest, and receives the termination of a vessel three or four times longer than the body itself, which takes its rise at the external base of the cavity itself, apparently from the cellular substance, and, after a variety of convolutions in the neighbourhood of the mouth, opens into the recess. The second recess is the largest, and the vessel connected with it is more complicated. Its origin is in a mass, which occupies a considerable portion of the abdominal cavity, and which consists of a vessel forming a great number of complicated convolutions, liberally supplied with blood vessels. The duct which proceeds from this mass suffers a sudden thickening of its walls for a short space, after which it again contracts, and before it terminates in the recess, in a perforated glandular knob, it contains a pedunculated fleshy body with a sharp-pointed corneous extremity, probably capable of being protruded into the recess and cavity.

The parts which are considered as forming the female organs, or which are connected with the sexual cavity on the right side of the anus, consist of an ovarium divided into two lobes, each of which may be perceived to be again minutely subdivided. The oviduct is tortuous, and passes through a glandular body, which in the other gasteropoda is regarded as the testicle. The pedunculated vesicle gives out two ducts, one of which goes to the testicle, the other to the uterus. It is difficult to form even a conjecture regarding the uses of all this complicated sexual apparatus. The subject can only be elucidated by an attentive examination of the condition of the organs at different seasons of the year, and studying at the same time the habits of the animals.

The preceding description of the characters of the genus is taken from the anatomical details of Onchidium peronii, a species found creeping upon the rock under water in the Mauritius, by M. Peron. The genus was first instituted by Dr. Buchanan in the *Linnean Transactions*, vol. v. p. 132, for the reception of a species which he found in Bengal, on the leaves of Typha elephantina. This species, however, if the description be accurate, differs essentially from the one described by Cuvier, and would lead us to infer that a new genus would be necessary for the reception of the species of the last mentioned naturalist. "This is not, (says Dr. Buchanan,) like many others of the worm kind, an hermaphrodite animal, for the male and female organs of generation are in distinct individuals. I have not yet perceived any mark to distinguish the sexes while they are in copulation, as, in both, the anus and sexual organs are placed in a perforation (*cloaca communis*) in the under part of the tail, immediately behind the foot; but during coition the distinction of sexes is very evident, the penis protruding to a great length, considering the size of the animal." Cuvier seems disposed to suspect the accuracy of these sentiments, and as they do not appear to have been the result of dissection, it would be desirable to have the doubts on the subject cleared up by a re-examination of the animal in question. Dr. Buchanan is probably correct in considering the tentacula as occillated.

Tribe II.—In this tribe the animals are furnished with a distinct external testaceous covering. The species which it includes were dispersed by Linnæus, through the genera Helix, Bulla, Voluta, and Patella, according to the characters furnished by the shell. They are now arranged under the following genera.

1. Lymnæus.—The shells of all the species are dextral. The animal is constructed so nearly on the plan of the snail, that it will be unnecessary to enter into any details of its structure, farther than to take notice of the more remarkable peculiarities. The tentacula are two

in number, lanceolate and depressed, and incapable of being withdrawn. The eyes are seated on the head, at the inner base, and a little in front of the tentacula. The mouth is furnished with three jaws, the two lateral ones simple, the upper one like the slug, crescent-shaped, with a notch in the middle. The male and female organs, though intimately connected, internally, have their external orifices separated to a considerable distance, the former issuing as usual under the right tentaculum, the latter occurring in a cavity near the the pulmonary opening on the side under the border of the cloak. In consequence of this arrangement, the individuals of *L. stagnalis* have been observed by Geoffroy and Muller to unite together in a chain during coition, the first and last members of the series exercising only one of the sexual functions, the intervening individuals impregnating and receiving impregnation at the same time. Whether this is the constant or only accidental practice of this species, does not appear to be determined. We know that many other species of the genus are mutually impregnated as usual in pairs only.

The species of this genus are numerous. They reside in pools, lakes, and rivers. They furnish a favourite repast to the different kinds of trouts and water-fowl. The following are natives of Britain. L. stagnalis, fragilis, palustris, fossarius, octanfractus, detritus, auricularius, putris, glutinosus, and probably Helix lutea, of Montagu.

With regard to the Lymneus auricularius, it would appear, from the observations of Draparnaud, "*Histoire des Mollusques*," p. 49, that it exhibits a very singular structure of the respiratory organs. We shall quote his own words. "L'animal est pourvu de quatre filamens ou tubes qui partent de la partie supériure du cou, près du manteau; ce sont des trachées. Ces tubes sont longs, blancs et tres-transparens, et on ne les distingue bien qu'a la loupe. Leur surface est comme rugueuse, et leur extrémité est un peu renflée. Ils sont rétractiles. L'animal les fait sortir à volonté, un, deux, trois ensemble: il les agite et les contourne sans cesse en divers sens: ce qui fait qu'on les prendroit pour de petits vers. Je présume que par ce mouvement ces organes séparent de l'eau l'air que y'est contenu et l'absorbent. Cet animal est très sujet, ainsi que les autres gasteropodes fluviatiles, à être infesté par le *nais vermicularis* qui se loge ordinairement entre le cou et le manteau, au dessous des tentacules, et s'agite sans cesse d'un mouvement vermiculaire." Little doubt, we think, can be entertained that this naturalist had been deceived by some of the parasitical leeches which infest the aquatic pulmonifera, and that, instead of breathing by means of tubular gills, the animal of the L. auricularius possesses, like those which it resembles in other characters, a pulmonary cavity.

II. Physa.—The shell of the animals of this genus nearly resembles that of the preceding, with these differences, however, that the whorls are sinistral, and the pillar lip is destitute of a fold. The external appearance of the animal is similar to Lymneus, but the margin of the cloak is loose, divided into lobes, and capable of being reflected over the surface of the shell near the mouth. The *Bulla fontinalis* of British conchologists, is regarded as the type of the genus which was instituted by Draparnaud.

III. Aplexa.—The shell of this genus is likewise sinistral, but it is more produced than the former, and possesses a fold on the pillar lip. The cloak of the animal is incapable of being reflected upon the shell, and its margin is destitute of lobes. This genus (from α and πλεξις, *lacinia*) has been instituted for the reception of the Bulla *hypnorum* and *rivalis* of British authors.

IV. Conovula.—This genus was instituted by Lamarck, for the reception of several species of fluviatile *volutæ*, as the *auris-midæ*. The shape of the shell is conical, the spire forming the base. The pillar is furnished with ridges. The form of the inhabitant is unknown.

V. Planorbis.—Independent of the character derived from the spires of the shell revolving in nearly the same horizontal plane, the animal is furnished with tentacula, which, unlike those of the preceding genera, are long and filiform, with the eyes, however, placed as usual on their internal base. It is a sinistral genus, the anus, pulmonary cavity, and sexual organs, being on the left, and the heart on the right side. Some of the species, particularly *P. corneus*, pour forth, when irritated, a purple fluid from the sides, between the foot and the margin of the cloak. In internal structure, the animals of this genus resemble those of the genus Lymneus. The British species are nine in number, and reside in shallow ponds and ditches, among aquatic plants, on which they feed.

VI. Segmentina.—We instituted this genus several years ago, for the reception of the *Nautilus lacustris* of Lightfoot, first described and figured in *Phil. Trans.* vol. lxxvi. p. 160. tab. i. fig. 1—8. The shell externally bears a close resemblance to a Planorbis, but, internally, it is divided into distinct chambers by solid transverse septa, which communicate with each other by a triradiated aperture. The animal possesses the same filiform tentacula with the eyes at their base, which distinguish the species of Planorbis, but it is uncertain whether the openings on the side be dextral or sinistral.

VII. Ancylus.—The shell in this genus is a short compressed cone, nearly resembling the commen Limpet. The tentacula are short, compressed, a little truncated, with eyes at the internal base. The foot is short and elliptical. This genus was instituted by Geoffroy, and includes the *Patella lacustris* and *oblonga* of British writers.

Subdivision II.—Gasteropoda Branchifera.

The animals of this subdivision are chiefly inhabitants of the ocean a few, however, are found in fresh water lakes and streams. They admit of distribution into the following orders.

I. Order. *Nudibranchia.*

This order chiefly contains those animals which Linnæus included in his genus Doris. Since the writings of the illustrious Swede, many new species have been discovered, rendering the construction of several new genera necessary.

All the animals of this order are destitute of a shell or corneous plate on the back.* The head is furnished with tentacula. The branchiæ are external, and consist of simple or compound filaments arising from the cloak on the sides or back. In many species, the back is covered with perforated papillæ, which probably give rise to a mucous secretion. All the species are hermaphrodite, with reciprocal impregnation. The external opening of generation is situated at the right side. In two genera, Doris and Polycera, the anus is situated on the back, and surrounded by a disk fringed by the branchiæ. In the other genera the anus is situated on the right side.

I. Doris.—This genus, as now restricted, contains such animals as have the anus on the back towards the tail, surrounded only with a fringe of plumose branchiæ. The cloak is more or less covered with papillæ, which the animal has the power of contracting at pleasure. It is divided from the foot by a distinct duplicature. Towards the anterior margin are the two superior tentacula, which are likewise retractile. Each, at the base, is surrounded with a short sheath, supported on a slender stem, with an enlarged compound plicated summit. The neck is short, and above the mouth is a small projecting membrane, connected at each side with the inferior tentacula. These tentacula are in general small, and in some cases it is difficult to detect them.

The mouth is in the form of a short trunk, leading to fleshy lips, within which the tongue is placed. It is covered with minute reflected hairs, and, from its motion, appears to be destined exclusively for deglutition. The gullet is a simple membraneous tube, terminating in a stomach presenting on the interior a few longitudinal folds. It is furnished with a small cæcum, whose extremity receives the bile from the liver. The stomach likewise receives the secretion of another gland, which is not connected with the liver. It is in the form of a small bag, whose inner surface is covered with numerous papillæ. The intestine is lodged in a groove on the surface of the liver, and proceeds directly to the anus.

The liver itself is divided into two lobes, and gives rise to numerous biliary ducts, which proceed to the stomach. But it likewise gives rise to a duct which proceeds to a small bag plaited on the inside, and afterwards opens on the surface at a small hole near the anus. It yet remains to be determined, whether the fluid carried off by this conduit be excrementitious matter, separated by the liver, or whether the gland which produces it be distinct from that organ, but so interwoven therewith as to elude the observation of the anatomist.

It is obvious, from the structure of the digestive organs, that the species subsist on soft food, requiring neither cutting nor grinding, and in this respect differ remarkably from the species of the genus Tritonia, which were formerly arranged along with them.

The organs of generation differ little from the other hermaphrodite gasteropoda. The vesicle furnishes two canals, one of which goes to the testicle, the other to the penis. There is likewise a minute bag connected with the canal of the latter. They deposit their spawn on sea-weeds and stones. It is gelatinous, of a white colour, and in appearance resembles the Spongia compressa.

The species of this genus are numerous, although their specific characters are still imperfectly ascertained. The following species have been detected in the British seas.

1. *Doris argo.*—Body about three inches in length, nearly smooth, and of a lemon-yellow colour. The anal plumes about twelve in number. It is called sea-lemon. Pennant's *Brit Zool.* iv. p. 43. tab. 22.

This species is not uncommon in the crevices of the rocks about low-water-mark.

2. *Doris verrucosa.*—Body about one inch in length, the cloak closely covered with tubercles; superior tentacula, smooth at the base, compressed at the summit. The vent surrounded with about twenty-four plumes.

The species which Cuvier has figured under this name, *Mem. sur le Genre Doris*, tab. 1. fig. 4, 5, 6, 7. is represented as having only sixteen anal plumes. Equally common with the preceding in the same situation. Frequently cast ashore after storms.

3. *Doris lævis.*—Body about half an inch in length, and widest in front. Foot narrow. Cloak smooth in the middle, tuberculated slightly towards the margin. The vent surrounded with eight plumes.

This species is figured by Muller, *Zool. Dan.* tab. 47. fig. 3, 4, 5. It is very common in company with the former among the Zetland isles.

4. *Doris marginata.*—Length about a quarter of an inch. Cloak smooth, tinged with pink, with an undulated membraneous border, usually four-pointed in front.

This species occurs on the coast of Devon, where it was observed by the late George Montagu, Esq. by whom it was described and figured in the *Linn. Trans.* vol. vii. p. 79. tab. vii. fig. 7 He refers to the figure D. lævis in the *Zoologia Danica* as synonimous, but with doubt. We have no hesitation, however, in considering them as distinct. The D. electrina of Pennant is, however, probably a variety, but the brevity of the description and imperfection of the figure which he has given render reference uncertain.

5. *Doris nodosa.*—Length about half an inch. Foot broad, emarginate in front. Cloak with four equidistant papillæ, on each side a mesial line. Plumes of the vent about nine in number.

This is another species discovered by Montagu, *Linn. Trans.* vol ix. p. 107. tab. vii. fig. 2.

6. *Doris quadricornis.*—Length about three-eighths of an inch. Cloak smooth in the middle, with a row of obsolete tubercles on each side. Tentacula approximated in pairs. Vent surrounded by eight or nine plumes.

This is a rare species, and is described and figured by Montagu, *Linn. Trans.* vol. xi. p. 17. tab. iv. fig. 4.; probably the type of a new genus.

7. *Doris nigricans.*—Length about half an inch. Cloak thickly covered with short lanceolate tubercles. Above the head emarginate. Sheath of the superior tentacula notched in the margin. Anal plumes about eight in number. Body pale, frecked with dusky.

We have found this species in the Zetland seas, and have not met with any description with which its characters correspond.

II. Polycera.—This genus is nearly allied to the former. It was instituted by Cuvier, for the reception of those species whose anus is surrounded with plumes, but which possess, in addition, two membranaceous plates wherewith to cover them. The superior tentacula are similar to those of the Doris, but the inferior ones, surrounding the mouth above, are more numerous, extending from four to six.

This genus contains fewer species than the preceding. Two, however, have been detected as natives of the British seas.

1. *Polycera flava.* Length about half an inch. Feelers above the mouth four in number; superior feelers two, awl-shaped. Anal plumes seven, behind which are two long smooth appendages.

This species is described and figured by Montagu, *Linn. Trans.* vol vii. p. 79. tab. vii. fig. 6. The figure exhibits two black dots behind the tentacula, probably intended for eyes, although no notice is taken of them in the description.

2. *Polycera pennigera.*—Length half an inch. Cloak pointed behind; contracted at the tentacula, and emarginate in front. Tentacula subclavated and perfoliated, with a sheath of two leaves. Anal plumes five, with two bifid appendages.

Described and figured by Montagu. *Linn. Trans.* xi. p. 17. tab. iv. fig. 5.

In those genera of this order, in which the anus is situated on the right side, and unconnected with the branchiæ, some, as the Tritonia and Scyllea, are furnished with corneous jaws, while in the thethys, there are only muscular lips. The mouth in the other genera has not been examined with sufficient attention. The presence of jaws, however, is an important addition to the digestive organs, enabling the animals to cut the substances on which they feed, while the others must swallow their food entire.

III. Tritonia.—This genus was instituted by Cuvier, for the reception of those animals formerly arranged under the genus Doris, which have the branchiæ disposed on each side the cloak. Many of the species possess eyes, or at least black points which are regarded as such. There are two superior tentacula, as in the Doris, which are in part retractile, and above the mouth sometimes another pair, or in their stead plumose appendages.

The mouth consists of two lips, which are placed longitudinally, and open into a short canal. Within are the jaws, which consist of two corneous plates united at the upper dorsal edge, slightly arched, and meeting at their upper margin, for the purpose of cutting. Within these is the tongue, which differs remarkably from the same member in the Doris. In the latter, the spines with which it is beset are reflected, and draw the food to the gullet, while in the former, the spines are deflected, and serve to keep the food within the reach of the jaws. The tongue of the Doris therefore serves for deglutition, that of the Tritonia for mastication. M. Cuvier, by mistake, describes the functions of both as similar. The salivary glands are placed on each side the gullet, and empty their contents behind the jaws. The gullet has a few longitudinal folds, the stomach is simple, scarcely different from the gullet, and the intestine proceeds almost directly to the anus, situated on the right side. The liver is small and situated behind, enveloping the stomach, and intimately united with the ovarium. The organs of generation exhibit nothing remarkable. The pedunculated vesicle has a simple canal. The external opening of the organs of generation is situated a little before and beneath the anus.

The following species are natives of the British seas:

1. *Tritonia arborescens.* Length about an inch. Margin above the mouth, with four plumose appendages. Foot narrow, sides compressed. Cloak smooth, soft, with five or six plumose tubercles on each side, decreasing in size towards the tail. Tentacula two, feathered, contained in a sheath.

This species is described and figured by Cuvier, in his *Memoire sur la Scyllée*, p. 27. tab. 1. fig. 8, 9, 10. We have found this species in the Zetland isles, agreeing with the characters of Cuvier, with this difference, that the branchiæ in his are only five, while in ours they appeared to be six on each side. But as the two posterior ones are very small, and as his examples were preserved in spirits, it is probable that they have escaped detection.

2. *Tritonia pinnatifida.* Length three-tenths of an inch. Tentacula filiform, inserted in a trumpet-shaped sheath. Branchiæ in a single row on each side, ovate, consisting of grey papillæ with black lips, arranged in five or six whorls.

First described and figured by Montagu, *Linn. Trans.* vol. vii. p. 78. tab. vii. fig. 2, 3.

3. *Tritonia bifida.* Length about a quarter of an inch. Tentacula (sheath?) two, broad, erect, and bifid, behind which are two eyes. Branchiæ in a single row, on each side, ovate, pedunculated, unequal; opposite pairs equal, summit semitransparent, uniform on the surface, but complicated within.

First observed by Montagu. *Linn. Trans.* vol. xi. p. 198. tab. xiv. fig. 3.

M. Cuvier has separated from the genus Tritonia such species as possess four tentacula; two superior, and two at the anterior extremity of the body. The branchiæ are placed in transverse rows along the sides and back. He likewise states, that there is no cloak, or rather no marked division between the cloak and the foot. This genus he has termed *Eolida.* Unfortunately none of the characters which are here selected, appear to mark any particular plan of organization; and the species to which he refers, differ as widely from one another as they do from the Tritoniæ. Three of his references are to British species, which we shall now describe. In all of these the branchiæ are simple, neither in the form of imbricated processes, nor plumes.

4. *Tritonia papillosa.* Length nearly three inches. Anterior tentacula smooth, superior ones annulated. Middle of the back smooth, sides thickly set with conical lengthened branchiæ, which, when closely examined, appear to be disposed obliquely in rows, containing about ten in each.

"From the points of the papillæ, (says Montagu,) an extremely viscid secretion is discharged, that sometimes envelopes the whole animal." We have observed it possess the horny jaws of a Tritonia.

This species is not uncommon at different parts of the coast. It was probably first observed as British by Turton, who appears to refer to it in his *British Fauna*, under the name Doris vermigera. It is described and figured by various authors, particularly by Baster. *Opuscula Subseciva*, i. p. 81. tab. x. fig. 1. A. B. C. D. Muller, *Zoologia Danica*, tab. cxlix. fig. 1, 2, 3, 4. Montagu, *Linn. Trans.* vol. xi. p. 16. tab. iv. fig. 3.

5. *Tritonia plumosa.* We have observed in Zetland this small species, which is about half an inch in length. It resembles the preceding in form, but has only one row of simple branchiæ on each side. The superior tentacula were pinnated towards the summit. The anterior ones simple. Opportunities for a more minute examination did not occur. The structure of the superior tentacula forbid us to regard it as the young of the T. papillosa.

6. *Tritonia cœrulea.* Length about a quarter of an inch. Tentacula simple, with eyes behind the superior pair. Branchiæ clavate in transverse rows on the back. Two oval vesicles on the right side, between the second and third row of branchiæ.

Described by Montagu, *Linn. Trans.* vol. vii. p. 78. tab. vii. fig. 4, 5.

7. *Tritonia longicornis.* Length half an inch. Ante-

rior tentacula about half the length of the body; the superior pair short, with the eyes behind. On the right side, near the eyes, a cluster of short papillæ. Branchiæ on the back in four transverse rows.

Described by Montagu, *Linn. Trans.* vol. ix. p. 107. tab. vii. fig. 1.

It is probable that the cirri on the right side, in this and the preceding species, mark the anus, and furnish a character for a generic distinction.

8. *Tritonia pedata.* Length about half an inch. The four tentacula subclavated and wrinkled, with eyes behind the superior pair. Branchiæ in four fasciculi, imperfectly connected transversely. Foot with two fleshy lobes in front.

This species is described by Montagu. *Linn. Trans.* vol. xi. p. 197. tab. xiv. fig. 2.

IV. Tergipes.—This genus was instituted by Cuvier, for the reception of those species which have only two tentacula, and a single row of branchiæ on each side, which act likewise as suckers, and enable the animal to crawl on the back. Forsthal described one species in his *Descriptiones Animalium*, p. 99, as Limax tergipes. The species may be distinguished by the number and form of the branchiæ.

1. *Tergipes maculata.* Length about a quarter of an inch. Tentacula filiform, retractile, with a trumpet-shaped sheath. Branchiæ nine on each, and consisting of a clavate sheath, with a sexpartite margin, a concave summit, with a single papilla in the centre.

Described by Montagu. *Linn. Trans.* vol. vii. p. 80. tab. vii. fig. 8, 9.

V. Thethys. This genus is characterised by a row of branchiæ on each side the back, and a large membranaceous expansion above the mouth, bearing two tentacula towards its base.

This genus was first instituted by Linnæus, but it is to M. Cuvier that we owe the discovery of its most important characters.

The body is ovate, with the cloak and foot continuous. The neck is distinct from the foot, and is narrow. Above, the neck is continuous with the cloak, from which arises a large semicircular expansion, which the animal probably uses as a fin. The margin of this expansion is fringed with numerous filaments, and on the upper surface, within the border, is a row of conical tubercles. The true tentacula are placed towards the base of this fin near the neck. They consist each of a small fleshy cone, striated across, with a semicircular sheath behind. The branchiæ consist of tapering fleshy stalk, spirally twisted towards the summit with a series of filaments on one side. They are fourteen in number on each side, alternately and oppositely small and large. The anus opens in front of the third branchia on the right side. The orifice of generation is exhibited under the first branchia of the same side. In the front of each of the larger branchiæ is a small cavity, with a small filament in the centre.

The mouth is situated underneath the tentacula. It consists of a large funnel, covered within with soft papillæ, destitute of jaws or tongue. The gullet is short, the stomach simple, fleshy, and covered with a thick cuticle. The salivary glands are slender and branched, and open into the gullet. The intestine is likewise short, and proceeds directly to the anus. The liver pours the bile into the canal at the pylorus; and likewise sends out another duct, which opens externally near the anus. The organs of generation are similar to the Doris.

The Thethys fimbria is the only species of the genus which has been satisfactorily ascertained.

VI. Scyllea. The distinguishing characters of this genus depend on the two tentacula, the mouth being furnished with jaws, and the back with membranaceous expansions, bearing on their upper surface the branchial papillæ.

The foot is very narrow, forming a groove on the under surface. The body is ovate, and compressed laterally. There are two expansions or crests on each side, and one at the tail. The branchiæ are in the form of plumes, covering the upper surface of the crests and the back. The tentacula are each contained within a large funnel-shaped sheath.

The mouth is placed at the base of the tentacula, surrounded with a semicircular lip. The jaws are horny, and cut by crossing each other. The tongue is furnished with reflected points. The gullet is longitudinally plaited. The stomach is short and cylindrical, with a ring of hard longitudinal scales. The liver consists of six unequal globules. The bile is poured into the cardiac extremity of the gullet.

The Scyllea pelagica has been long known to naturalists, and appears to be very common in the equatorial seas. It is commonly found adhering to the stems of the fucus natans.

VII. Glaucus. In this genus, whose true characters are still imperfectly explored, the head is furnished with four simple tentacula. On each side the body are three or four horizontal membranaceous expansions, whose margins are fringed with the branchial filaments.

This genus was instituted by R. Foster, and the species with which naturalists have been longest acquainted, is the Doris radiata of Gmelin, which is figured in the *Phil. Trans.* vol. lii. tab. iii. It is not uncommon in the Atlantic Ocean.

It is probable that a more minute examination of the animals of this order, than has hitherto taken place, would lead to the formation of several tribes and families. The number of the tentacula, the structure of the mouth, the connection between the cloak and the foot, the appendages of the anus, and the disposition of the branchiæ, lay claim to the notice of the systematical zoologist. But the study of these animals can only be carried on at the sea-shore, where they can be preserved alive in their native element.

II. Order. *Cyclobranchia.*

The animals of this order differ from the preceding in the marginal distribution of the branchiæ. Between the foot and the cloak, or dorsal covering of the body, the gills are placed, above the one, and beneath the other. These are in the form of little leaves, which constitute a fringed band on each side of the body; in some surrounding the whole body, in others interrupted front or behind. Independently of this remarkable position of the organs of respiration, M. Cuvier arranges the animals in which it occurs into two distinct orders, and places them far apart in his system. It is not easy to account for this distribution; as the only character of importance by which he has marked their separation, is derived from the circumstance, that, in the animals of his first order, the sexes, though united, require the mutual union of individuals, while, in the other, each individual is *supposed* to be capable of impregnating itself. In these last, however, the other organs, of feeling, digestion, or protection, have no common properties. Averse to any arbitrary arrangements of this kind, we have here brought them together under one order, and shall now proceed to consider the characters of the genera.

1. Phyllidia. The body, in the animals of this genus, is ovate. The foot is narrow in front. The cloak is broad, coriaceous, and destitute of a shell. Towards its anterior extremity are two cavities, from which issue the retractile superior tentacula, as in the genus Doris. Nearly at the posterior extremity is another cavity, containing the anus. This opening, though similar in situation to that of the Doris, is merely a short simple tube. The head is immediately above the anterior margin of the foot, above which is the mouth, having a small conical feeler on each side. Under the margin of the cloak on the right side, and about half way between the mouth and the middle of the body, are two openings, in a tubercle, for the organs of generation. The branchiæ consist of slender complicated leaves, which surround the body between the foot and the cloak. The circle is interrupted at the head and the tubercle of generation.

The mouth is destitute of jaws. The gullet is simple, ending in a membranaceous stomach. The pylorus is placed near the cardia, and the intestine goes directly to the anus. The salivary glands are small, and placed near the mouth. The liver is large in proportion.

The heart is placed in the middle of the back. The auricle is simple, placed on the side next the tail, and supplied by the two systemic veins which collect the aërated blood from the branchiæ on each side. There is a simple aorta arising from the opposite side of the heart.

The organs of generation appear to be similar to those of the preceding class; but they have not as yet been minutely examined. The existence of eyes is not satisfactorily determined.

The animals of this genus appear to be inhabitants of the tropical seas. Cuvier has given descriptions and figures of three species, which differ remarkably from one another in the protuberances of the cloak.

2. Diphyllida. This genus was formed by Cuvier in his *Regne Animal*, for the reception of an animal in the cabinet of M. Brugmans at Leyden. It is but imperfectly characterized. The cloak is pointed behind; the head semicircular, with a feeler, and small tubercle on each side. The anus is placed on the right side.

3. Patella.—*Limpet*. This genus differs from the others of this order, in being covered on the back by a conical shell, within the cavity of which the animal is capable of withdrawing itself. The cloak is large, covering both the head and foot. It is united with the shell along its superior margin. The foot is fleshy, and furnished with numerous muscular filaments, which unite in the superior part of the cloak, to form a strong muscle, by which the body adheres to the shell. The action of this muscle brings the shell close to the surface to which the foot adheres, or removes it to a distance.

The head is furnished with a large fleshy snout, supporting at the base two pointed tentacula. The eyes are placed on a small elevation at the external base of the tentacula. A little way behind the head, and below the cloak, on the right side, are two apertures, being the anus and orifice of generation. The gills occupy the same position as in the preceding genera. In some the branchiæ form a complete circle; in others the circle is interrupted anteriorly at the head.

Within the trunk, the mouth is fortified by two cartilaginous cheeks, which, at their union, anteriorly, support the base of the tongue. This last is a most singular organ. It is longer than the whole body, narrow, and covered with three rows of short reflected spines, interrupted longitudinally and transversely. Its fixed end only is exercised, its free end being coiled up the abdomen. On the upper side of the mouth is a semicircular osseous plate, or upper jaw. The gullet is furnished with a dilatable pharynx. The stomach is elliptical, with the cardia and pylorus at opposite extremities. The intestines are variously folded, and are several times longer than the body. The salivary glands are minute. The liver is intimately united with the stomach and intestines.

The heart is situated on the left side, in the anterior part of the body. The auricle receives the aërated blood from one vein when the circle of the gills is complete, and by two when interrupted. This auricle is placed on the anterior side of the heart. An aorta arises from each side, to convey the blood to the body.

The ovarium is placed underneath the liver; and as it exhibits some differences of organization, M. Cuvier infers that it likewise contains the male organs.

The species belonging to this group are numerous, and appear to admit of distribution into those having the branchial circle complete, and those in which it is interrupted.

4. Chiton. This genus is well characterised by a series of testaceous dorsal plates, and the absence of tentacula.

The body is elliptical. The cloak is firm and cartilaginous, and variously marked on the margin. The dorsal plates are arched, and occupy the middle and sides of the back. They are implanted in the cloak in an imbricated manner, the posterior margin of the first valve covering the anterior margin of the second. The foot is narrow. The mouth is surrounded with a semicircular curled membrane. The anus consists of a short tube, placed at the posterior extremity of the foot, which supplies the place of tentacula. The external orifice of generation has not been ascertained.

The mouth is capable of forming a short proboscis. The tongue is short, and armed with strong reflected spines. The gullet is short, and the stomach, which is lengthened and folded, is membranaceous. The intestine is several times longer than the body, and much folded. The liver is divided into numerous lobes, and intimately united with the stomach and intestines.

The heart is situated at the posterior part of the body. The auricle is placed posteriorly, and receives the aërated blood from two veins. Each vein descends along the base of the gills, collecting the aërated blood from the particular side of the body to which it belongs; and, what is most remarkable, when opposite the ventricle, it suffers an enlargement, and sends off a branch which communicates with it, and again contracts and unites with its fellow from the opposite side to form the auricle. A single aorta arises from the anterior side.

The ovarium is conical, and divided into numerous lobes. Behind, two ducts seem to arise, and to proceed one to each side; but it has not been determined whether they open externally. No male organs have been detected; nor is there any thing accurately known with regard to the peculiar nature of their hermaphroditism.

There are several species of chitons described in the article CONCHOLOGY as natives of the British shores. Even these furnish characters by which they may be distributed into groups. 1. Marginal band of the cloak, with tufts of spines, as the *C. fascicularis*. 2. Marginal band rough, as *C. marginatus ruber* and *cinereus*. 3. Marginal band striated, as *C. lævis* and *albus*. 4. Marginal band smooth, as *C. lævigatus*. The first ought to constitute a new genus apart.

The two first genera of this order, Phyllidia and Dephyllidia, are destitute of shells, and constitute the order Pleurobranchia of Cuvier. The two last, Patella and Chiton, are furnished with shells. They form the order Cyclobranchia of Cuvier. We have ventured to unite them under the latter denomination, being persuaded that the only character common to all of them is derived from the position of the gills, and that Patella and Chiton differ as much in the structure of their other organs from each other, as they do from either Phyllidia or Diphyllidia.

The only animal in this order which is valuable in an economical point of view, is the limpet. Although used by the ancients as an article of food, it is seldom brought to market in this country. The inhabitants along the coast, however, frequently use it as food when boiled; and its juice obtained by this means, when mixed with oatmeal, forms a dish known in Scotland by the name of *Limpet Brose*. It is in season about the month of May. It is much used as a bait in catching littoral fish.

ORDER III. *Tectibranchia*.

This order may be considered as represented by the genera Aplysia and Bulla of Linnæus. In many of the order Nudibranchia, the respiratory organs form a double row on each side the back. In the Cyclobranchia, the same organs occur on each side, but underneath the cloak. In the present order, the branchia occur underneath the cloak, but they are confined to a particular portion of the right side. They are all inhabitants of the sea. They exhibit the same hermaphroditism as the Nudibranchia. The order consists of the following genera.

1. PLEUROBRANCHUS.—This genus is particularly characterised by the foot and cloak forming two broad plates, which inclose the body. Between these, in the middle of the right side, the branchiæ are placed. The tentacula are two in number, with eyes at the base behind.

The cloak is strengthened in the middle above the branchiæ by a thin expanded subspiral shell. The neck is short, and in some contracted, with the front emarginate, exhibiting the commencement of the inferior tentacula. The upper tentacula are tubular and cloven. The gills occur at the edge of the dorsal plate. In front of these are the orifices of the organs of generation, and immediately behind the gills the anus is situated.

The mouth is furnished with a short retractile proboscis. The tongue occupies both sides of the mouth, and is covered with spines. The gullet is enlarged into a kind of crop before it enters the stomach. This is folded, and is divided by contractions into three parts. The first has muscular walls of moderate thickness, with a single longitudinal band. In the second the walls are membranaceous, with longitudinal internal ridges. The third stomach has thin and simple walls. The gut is short. The salivary glands are situated at the folds of the stomach, and empty their contents into the mouth by two canals. The liver is placed on the stomach, and empties itself into the lower part of the crop.

The heart is nearly in the middle of the back. Its auricle is on the right side, at the base of the branchiæ, and the ventricle sends out at the opposite side three arteries.

M. Cuvier has figured and described the P. peronii with its anatomical details. Two species likewise appear to be known as natives of the British seas.

1. *Pleurobranchus plumula*.—Foot pointed behind. Gills in the form of a compound plumose appendage. The cloak contains the shell known to British writers as the Bulla plumula of Montagu, and figured and described in *Testacea Britannica*, p. 214. Vignette 2. fig. 5.

2. *Pleurobranchus membranaceus*.—Foot rounded, with an irregularly indented margin. Cloak covered with conical papillæ. Gills a plumose appendage.

This species was found by Montagu at Kingsbridge, Devonshire, in 1809, and is described and figured by him in the *Linn. Trans.* vol. xi. p. 184. tab. xii. fig. 3, 4.

We have been induced to refer the two species to this genus, as agreeing generally with the characters assigned to it by Cuvier. There is, however, one particular in which they greatly differ. Cuvier states, that the gills in his Pleurobranchi—" sont attachées le long du côté gauche (droit!) dans le sillon entre le manteau et le pied, et representent une serie de pyramides devisées en feuillets triangulaires." *Regne Animal*, iii. p. 396. His representation of the P. peronii, in his Memoires, accords with the preceding description. But in the two British species, the gills appear like a feather, free at one extremity. They may be permitted to remain, therefore, in the genus Lamellaria, which Montagu instituted for their reception, unless we suppose that Cuvier, from inspecting only shrivelled specimens preserved in spirits, overlooked the true structure of the gills, a conjecture we consider as highly probable.

II. APLYSIA. Tentacula four, the eyes placed in front of the two superior ones. Mouth longitudinal.

The body of the Aplysia is ovate, acuminated behind, and produced before to form a neck. The foot is narrower than the body. In the middle of the back is a corneous plate enclosed in a bag in the skin, and on each side, and behind, there is a fold by which this part may be concealed. The head is slightly emarginated, with a feeler on each side. The superior feelers are situated on the neck. In front of each of these is a small black point or eye.

The branchiæ are situated underneath the dorsal plate, on the right side, and exhibit a complicated plumose ridge, capable of expansion beyond the edge of the plate. The anus is situated immediately behind the branchiæ, and before them is the orifice of generation, from which proceeds a groove along the neck to the inferior base of the fore-feeler, on the right side, where there is an opening for the penis.

Within the longitudinal lips are two smooth corneous plates, the substitutes for jaws; the tongue is rough, as in many of the other gasteropoda. The gullet is short, and suddenly expands into a large subspiral crop, with membranaceous walls. To this, a gizzard with muscular walls succeeds, the interior of which is armed with numerous pyramidal teeth, with irregular summits, of a cartilaginous nature. The connection between these teeth and the integuments is so slender, that they are displaced by the application of the smallest force. They however project so far into the cavity, as to offer resistance to the progress of the food. There is yet another stomach, armed on the one side with deflected, pointed cartilaginous teeth. At the pyloric extremity are two membranaceous ridges, between which are biliary orifices, and the opening into a long narrow cæcum, with simple walls, which is contained within the lever. The intestine is simple, and after two turns ends in a rectum.

The salivary glands are very long, and, as usual, empty their contents into the pharynx. The liver is divided into three portions by the folds of the intestine, each of which consists of several lobes. The biliary vessels are very large, and open at the mouth of the cæcum into the last stomach. The food of the Aplysia consists of sea-weeds and minute shells.

The circulating organs are remarkable. On each side the body, in the region of the dorsal plate, there is a large vessel, which receives blood from different parts of the body, and which likewise, by various openings, has a free communication with the cavity of the abdomen. In this respect there is a resemblance to the spongy glandular bodies of the venæ cavæ of the cephalopoda. These two vessels, or *venæ cavæ*, unite posteriorly, and transmit their contents to the gills. The aërated blood is now conveyed to an auricle of large dimensions, and uncommonly thin walls, situated beneath and towards the front of the dorsal plate, and emptying its contents through a valve, into the right side of the ventricle. The aorta, which issues from the left and anterior side, divides into two branches, the smallest of which proceeds to the liver on the left. The larger branch is again divided, the smaller branch proceeding to the stomach. The largest trunk that remains, before it leaves the pericardium, has two singular bodies attached to it, consisting of comparatively large vessels, opening from this aortic branch. The use of these glands is unknown.

The organs of generation likewise exhibit some remarkable peculiarities. The ovarium is situated in the posterior part of the abdomen. The oviduct is tortuous in its course, passes along the surface of the testicle, and after uniting with a clavate appendage, opens into a common canal. The testicle is firm, apparently homogeneous in its texture, of a yellow colour, with spiral ridges on its surface. The vas deferens arises from a complex glandular body, and unites with the common canal. This common duct, before it reaches the external orifice, receives the contents of the pedunculated vesicle, and has attached to it a botryoidal glandular organ, whose use is unknown, but which some suppose to be employed to secrete an acrid liquor regarded as venomous.

It is obvious from this structure, that the seminal fluid and eggs must come in contact in the common canal, and at the single orifice, provided they are both ejected at the same time. From the orifice to the right fore-feeler there is a sulcus, leading to the pore containing the retractile penis. This organ, like those of the other mollusca, is solid. It terminates in a small filament. The external groove is the only connection between it and the other sexual organs.

There is a peculiar secretion of a purple fluid, which here deserves to be recorded. It issues from a spongy texture, underneath the free side of the dorsal plate. Connected with this cellular reservoir is a grandular body of a considerable size, which is supposed to secrete the coloured fluid. This gland is supplied by a large branch of the glandular aorta, and gives out two very large veins to the left vena cava.

The purple fluid itself has never been carefully investigated. It is not altered by the air after drying, nor is its colour destroyed by acids or alkalies, although the tint is a little changed, and rendered less pure. Both these re-agents precipitate from the fluid white flakes.

This liquor is poured out by the animal when in danger, or constrained, and colours the water for several yards around. It ejects it readily when put in fresh water; and when entangled in a net, several yards of it in the neighourhood are sometimes stained, greatly to the amazement of the unsuspecting fishermen.

The Aplysia has been long known in the records of superstition under the name of the *Sea Hare*. Its flesh, and the inky fluid it pours out, have been regarded as deleterious to the human frame. Even to touch it was supposed to occasion the loss of the hair; while the sight of it would not fail to subdue the obstinacy of concealed pregnancy. The progress of science has exposed the errors, or perhaps tricks of the earlier observers, and proves the innocence of an animal formerly invested with every repulsive and noxious attribute.

The species of this genus are still involved in great obscurity. Those which inhabit the British isles appear to be the following.

1. *Aplysia depilans.* Dorsal plates covered in the middle. Body of a purplish-brown colour, with black dots. Length from five to six inches.

This is the most common species, and is found from the south of England to the shores of Zetland. It has a faint disagreeable smell.

2. *Aplysia punctata.* Body brown, with numerous white spots. Dorsal plate exposed in the middle. About the same size as the preceding.

This species was first figured and described by Cuvier, who regards it as distinct. The characters by which they are separated, however, are far from being trustworthy.

The colour in the depilans is subject to considerable variation, and in some cases the black spots disappear. The absence of the cuticle from the middle of the dorsal plate in the punctata, is probably the effect of accident or age.

Both kinds were observed by the late George Montagu, Esq. on the Devonshire coast, and from a letter of his now before us, dated 17th February 1811, he appears to have convinced himself that they did not constitute distinct species. The question can only be decided by the discovery of the intermediate varieties.

3. *Aplysia viredis.* This species is figured by Montagu, *Linn. Trans.* vii. tab. vii. f. 1. and described in the following terms: "With the fore-part of the body like a common *Limax:* tentacula or feelers two, flat, but usually rolled up, and appear like cylindric tubes; at a little distance behind the tentacula, on each side, is a whitish mark, in which is placed a small black eye: the body is depressed, and spreads on each side into a membranaceous fin, but which gradually decreases from thence to the tail, or posterior end: this membranous part is considerably amorphous, but is usually turned upwards on the back, and sometimes meeting, though most times the margins are reflected; this, as well as the back, is of a beautiful grass-green colour, marked on the superior part of the fins or membrane with a few small azure spots, disposed in rows; the under part

with more numerous, but irregular spots of the same: the fore-part of the head is bifid; the lips marked by a black margin: the sustentaculum is scarce definable, as it most commonly holds by a small space close to the anterior end, and turns the posterior end more or less to one side: it sometimes, however, extends itself for the purpose of locomotion, in which it scarcely equals a snail."

"Although this animal does not strictly correspond with the characters prefixed by Linnæus to the genus *Laplysia*, yet it approximates so nearly to the *Depilans* in its external form, that we cannot hesitate to place it with that animal, though we could not discern any membranaceous plate or shield under the skin on the back." The characters here assigned to this species are such as to excite the belief that it is not an Aplysia; but they are not sufficiently minute to enable us to establish another genus for its reception. It is to be hoped that some naturalist, who has an opportunity of visiting the south coast of Devon, where this species was found, will re-examine its characters, and communicate a more detailed account of its form and structure.

III. Dolabella. This genus differs from Aplysia, in the dorsal plate being calcareous and hard. The fore-part of the body is narrow—behind, it is larger, and truncated obliquely. The disk thus formed is circular, surrounded with a fringe of fleshy filaments. From the centre of this disk, a longitudinal slit extends forwards a little way beyond the anterior margin, and contains the branchiæ. The position and structure of the other organs are precisely similar to those of the Aplysia.

This genus was instituted by Lamarck, from characters derived exclusively from the dorsal plate or shell. Cuvier afterwards examined a species brought from the Mauritius by Peron, which he considers as the species figured by Rumphius in his Amboinshe Rariteitkamer, tab. x. No. 6. and which he has consecrated to his memory, naming it Dolabella Rumphii.

IV. Notarchus This genus is desitute of the dorsal plate, and contains an oblique groove on the neck, leading to the branchiæ. The internal structure resembles the Aplysia. This genus was instituted by Cuvier, in his *Règne Animal*, vol. ii. p. 395, and the only known species described, iv. tab. ix. f. 1.

V. Bulla. The animals of this genus differ from the preceding, in the absence of tentacula, and in the foot behind being furnished with a membranaceous appendage.

The body is oblong—becoming a little narrower in front. Below, the foot is broad, thin, and waved on the margin, expanded on each side behind, and capable of being turned upwards. At the posterior part of the foot, there is a broad membranaceous appendage, separated from it by a groove, part of which folds upwards, and a part is spread over bodies, like the foot. It assists in closing the mouth of the shell, and in its position and use is analogous to the operculum, in the following order. Above the foot, in front, but separated from it by a groove, is a flat fleshy expansion, which Cuvier terms the tentacular disk, considering it as formed by the union of the inferior and superior tentacula. In the centre of the disk, in the Bulla hydatis, (*Linn. Trans.* vol. ix. tab. 6. f. 1.) Montagu observed two eyes. Between this portion of the back and the posterior extremity, is the dorsal plate or shell, forming the genus Bulla of conchologists. This shell is covered by the integuments in some species, while in others it is exposed. But in all, the part containing it is partially concealed by the animal, by means of the reflected margins of the foot, and its appendage. Along the right side of the body there is a groove formed by the foot, and its appendage on one side, and the dorsal plate and tentacular disk on the other. The branchiæ are situated in a cavity under the shell or dorsal plate, and resemble those of the Aplysia. Behind the gills, in the lateral groove, is the anus, and in front of these, the orifice of the united organs of generation. The penis is removed as in the Aplysia, and connected by a similar slit.

The mouth is, as usual, in front, above the foot and beneath the tentacular disk, both of which serve as lips. The cheeks are strengthened on each side by a corneous plate. The tongue is well developed in some, as the B. ampulla, while in the B. aperta it is reduced to a small tubercle. The gullet is large, and in the B. ligniaria makes two folds before entering the gizzard. This last organ is fortified by three testaceous plates, convex and rough on the inner surface, and attached to strong muscular walls. These plates exhibit in the different species considerable varieties of form and markings. The intestine, before terminating in the anus, makes several convolutions in the substance of the liver. The salivary glands exhibit considerable differences. In the *B. ampulla*, they are long and narrow, and their inferior extremity fixed to the gizzard. In the *B. aperta* and *lignaria*, they are short, with the extremity free. In the *B. hydatis* they are long, unequal, and the extremity of the one belonging to the left side is forked. The liver forms a part of the contents enclosed in the spire of the shell. It envelopes the intestine, and empties the bile into its pyloric extremity.

The auricle and ventricle appear to occupy the same relative position as in the Aplysia, but the structure of the arteries is unknown. The organs of generation have also so near a resemblance as to forbid a detailed description. Some species are said to eject a coloured fluid like the Aplysia, from the lid of the branchiæ. A gland is observed in the Bulla lignaria, similar to the Aplysia, in which it is probable the fluid is prepared.

The species of this genus have not been sufficiently investigated in a living state. When preserved in spirits, it is impossible to form a correct idea of their true appearance, as exhibited when alive in sea-water, since they usually exist as a shapeless mass. Cuvier has given delineations of such preserved species, but they bear no resemblance to the figures of Montagu, of the same species, taken from living objects.

M. Lamarck is inclined to subdivide this genus into two, distinguishing those in which the shell is concealed by the term *Bullæa*, from such as have the shell in part exposed, which he retains in the genus *Bulla*. The Bulla aperta of British conchologists is an example of the former, and B. lignaria of the latter. The shells of the genus Bullœa are thin and white—those of Bulla stronger, more opake, and covered with an epidermis, which, after the death of the animal, is easily detached.

VI. Doridium. In the animals of this genus, there is no dorsal plate or shell, although there is a cavity with a spiral turn in the cloak. The branchiæ and accompanying organs are nearer the posterior extremity than the species of the preceding genera.

The digestive system is more simple than in the preceding genus. There is here no appearance of the spinous tongue, the gullet is short, and the stomach is membranaceous.

The characters of this genus were first developed by

Cuvier, but the name which we have adopted is that of Mekel. Only one species, D. carnosum, is known as a native of the Mediterranean.

The preceding review of the genera of this order indicates the existence of at least three natural families. The pleurobranchia appears to stand apart, and to have few characters in common with the others, which are all intimately related. But under the head Aplysiæ, the genera Aplysia, Dolabella, and Notarchus, may be included, while the Aceræ will comprehend Bulla, Bullœa, and Doridium.

IV. Order. *Cervicibranchia.*

We have been induced to institute this order, for the reception of the genus Valvata of Muller. The species which it includes are inhabitants of fresh water, and in their general appearance resemble the aquatic pulmoniferous gasteropoda. They are distinguished, however, from all the other gasteropoda, by the position of the branchiæ, and the number of tentacula.

The branchiæ appear in the form of a feather, with a central stem, and a row of compound branches on each side, decreasing in size from the base to the extremity, which is free.

This plume is placed on the neck, near the middle, and a short way behind the anterior tentacula. Near this plume, but on the right side, is a single simple filament, like a tentaculum. The anterior tentacula occupy the usual position, and are setaceous. The eyes are placed at their base behind.

The animal is furnished with a spiral shell, into which it is capable of withdrawing the body. The foot is protected by a spirally-striated operculum, which shuts up the mouth of the shell upon the retreat of the inhabitant.

The species are all of a small size, and their internal structure has never been subjected to a rigorous examination. Two species are natives of Britain.

1. *Valvata cristata.* This is the Helix cristata of Montagu. The shell resembles a planorbis in its depressed form, the whorls revolving nearly on the same plane, so that the last-formed one embraces the others. The aperture is circular and simple. It is found in ditches on aquatic plants in England.

2. *Valvata piscinalis.* This is the Turbo fontinalis of British conchologists, but first described by Muller as Nerita piscinalis. The whorls of the shell form in this species a short spire. It is very common, both in England and Scotland.

V. Order. Pectinibranchia.

This order comprehends nearly all the animals with spiral univalve shells which inhabit the sea, together with a few which reside in fresh water.

The foot is usually fortified above, on its posterior extremity, with a corneous plate, which acts as a lid to the shell, when the animal is withdrawn into the cavity. The anterior extremity is in some of the species double. The anterior margin of the cloak forms a thick band, or arch, rising from the foot, behind which is the portion of the body that is always contained in the shell, and which is covered with a very thin skin. Between the margin of the cloak and foot is situated the head, supported on a short neck. The tentacula are two in number, bearing eyes at their base, or on short lateral processes, which have some claims to be considered as tentacula. The hood is frequently emarginated, and sometimes fringed. The mouth is more or less in the form of a proboscis, in some cases armed within with spinous lips, or furnished with a long narrow spiral tongue, armed with spines, as in the common periwinkle. The nature of this kind of tongue, whose spiral extremity is free and lodged in the abdomen, is not well understood.

The entry to the gills is by a large aperture between the margin of the cloak and neck, at the middle, or towards the right side. These are contained in a cavity on the back of the animal, and consist of leaves arranged in one or more rows, which adhere to the walls of the cavity. At the entrance of this cavity is the anus and oviduct.

The male and female organs are considered not only as distinct, but as occurring on different individuals. The evidence in support of this opinion is in many cases complete. The penis is in some external, and incapable of being withdrawn, while in others it is retractile, and situated in a cavity in the right tentaculum.

The body of the animal is attached to the shell by means of two muscles, which adhere to the pillar near the same place, and shift their position, by an arrangement not well understood, in proportion as the individual increases in size. These muscles terminate in the foot and mouth.

The animals of this order have not been examined sufficiently in detail to admit of their distribution into natural groups, distinguished by characters founded on important differences of organization. The form of the shell has been resorted to, with the view of assisting arrangement. The characters thus furnished would be useful and valuable, were they the index of any peculiar internal structure. But, unfortunately, animals widely different in structure, inhabit shells of the same form, and *vice versa*, so that, however useful the mere conchologist may find the form of the shell to be in his arrangements, it can only be regarded by the zoologist as occupying a subordinate place. Without therefore entering into any details regarding the structure of the few species which may have been examined anatomically, we shall merely point out the tribes and families which have been contemplated, and whose characters in a great measure depend on the shape of the shell.

The first Tribe contains animals with spiral shells, having an entire aperture. The anterior margin of the cloak is likewise entire. It includes the greater part of those shells included by Linnæus in his genera Turbo trochus and Nerita.

The first Family of this tribe, represented by the genus Turbo, has the aperture of the shell nearly round. All the species are furnished with an operculum. Some are known to be ovoviviparous, and it is probable that all the species are so. Some have the sexes distinct, in different individuals, as the Palludinæ, while in others the female organs only have been detected. Some of the genera are marine, such as Turbo, Delphinula, Vermicularia, Turritella, Scalaria, Odostomia, and Monodonta. The animals exhibit remarkable differences in the form of the hood, the length of the peduncles supporting the eyes, and the filaments on the sides of the body.

There is only one genus, the species of which reside in fresh water, termed Paludina. It contains the *Helix vivapara* and *tentaculata* of British conchologists. Cuvier seems disposed to unite with this genus, the common marine shell Turbo littoreus or Periwinkle. The form of the foot and hood, however, are different, but more especially the tongue, which, in the Paludina, is a fixed tubercle, while in the periwinkle it is strap-shaped, free at one extremity, equal in length to the body, and covered with spines.

The second Family is represented by the Linnean genus Trochus The aperture of the shell is somewhat quadrangular. The foot of the animal is furnished with an operculum, (unless in the genus Pyramidella, in which it is supposed to be wanting,) and the body on each side is ornamented with filaments, usually three in number, resembling tentacula. All the species are marine, and are included in the genera Trochus, Solarium, and Pyramidella.

The third Family, termed Conchylium by Cuvier, is formed of shells having the aperture crescent-shaped, as in the genus Helix, in which they were formerly included. Two of the genera, Ampullaria and Melania, are fluviatile, residing in the countries near the equator. The remaining genera, Phasianella and Janthina, are marine. The Janthina vulgaris is destitute of an operculum, but in its stead it is generally furnished with a cellular spongy body adhering to the foot, which, in consequence of changes produced in its density by unknown means, enables the animal to rise to the surface of the water and float. When restrained, it throws out a purple fluid, like the Aplysia, lodged in the margin of the cloak, covering the gills.

This species has been added to the British Fauna by the late Miss Hutchins, who obtained many individuals from a herd of them which came into Bantry Bay. They have since been found on many other parts of the Irish coast.

We are disposed to place here, as a new genus, the *Bulla velutina* of Muller, figured and described in the Zoologia Danica, tab. ci. fig. 1, 2, 3, 4. It is the Helix lævigata of British writers. The foot is destitute of lid or appendage, and is broad before and pointed behind. The tentacula are two in number, short and filiform, with eyes at their external base. The head is broad and short. In addition to these characters given by Muller, we have been enabled to add the following, from a specimen, somewhat altered, which was found in the stomach of a cod-fish. The animal adheres to the shell by two linear muscles, one on each side the cloak. The branchial cavity is towards the left side. The tongue is spinous, narrow, with its free extremity spiral. Eyes rather behind the tentacula. Penis exserted on the right side of the neck, immediately behind the eye. Cloak large in proportion to the size of the foot. We have termed the genus *Velutina*, bestowing on the species the trivial name *vulgaris*.

The fourth Family includes the Neritæ of Linnæus, distinguished by the oblique straight pillar lip, and semicircular aperture, closed by an operculum. Two of the genera of this family, Natica and Nerita, are marine, while the Neritina, represented by the Nerita fluviatilis of Linnæus, lives in fresh-water streams.

The Second Tribe includes the spiral canaliculated univalves of conchologists. The aperture of the shell at its anterior margin is formed into a groove or canal. This structure is occasioned by the anterior margin of the cloak being produced over the aperture of the gills, for the purpose of acting like a syphon or tube, to convey the water to and from the branchial cavity. The species are considered as oviparous, with distinct sexes in separate individuals.

The first *Family* includes the genus *Conus* of Linnæus. The animals are furnished with a long proboscis, and tentacula, the latter bearing the eyes near the summit on the outside. The lid is placed obliquely on the foot, and is too small to fill the mouth of the shell. The species, which nearly amount to two hundred in numder, are all inhabitants of the seas of warm countries. They are now arranged under the genera Conus and Terebellum.

The second *Family*, represented by the genus Cyprea, contains likewise many species. The cloak of the animal is sufficiently large to admit of its extension over the surface of the shell. The animal casts its shell as it increases in size, and forms a new one suited to its dimensions, as we have formerly stated. When the shells are obtained before they have received their external coat, they have been regarded as new species. The foot is destitute of a lid.

The third *Family* consists of the genus *Ovula* of Bruguière. The animals of the different species are unknown. The shells have been distributed into the following genera by Montfort—Ovula, Calpurna, and Volva. The last includes a British shell, the Bulla patula of Pennant.

The fourth *Family* includes the Volutæ of Linnæus. The genera, which are the following, appear to be destitute of a lid. Voluta Oliva, Cymbium, Marginella, Cancellaria, Colombella, Mitra Ancilla, Volvaria, and Tornatella.

The fifth *Family* is represented by the genus Buccinum of Linnæus. The canal is short, scarcely produced beyond the anterior margin of the lip, and bent towards the left. All the animals which have been examined are furnished with a retractile proboscis. The eyes are situated at the external base of the tentacula; and the foot is furnished with a lid. The following genera have been established in this family: Buccinum, Eburna, Dolium, Harpa, Nassa, Purpura, Cassis, Morio, Terebra, Cerithium, and Potamida. In the two last the head is furnished with a hood, of which the former genera are destitute.

The sixth *Family* consists of the genus Murex of Linnæus. The canal of the aperture is straight, and more or less produced. The inhabitants exhibit nearly the same form as those of the preceding family. The following genera appear to be formed on permanent characters: Murex, Typhis, Ranella, Fusus, Pleurotoma, Pyrula, Fasciolaria, and Turbinella.

The seventh *Family* includes the Strombi of Linnæus. These possess a canal which is short, and either straight or bent towards the right. The outer margin of the aperture is expanded with age, and exhibits a second canal, generally near the former, for the passage of the head. The following genera belong to this family: Strombus, Pterocera, Rostellaria.

The Third Tribe is represented by the Helix haliotoidea of Linnæus, now constituting the genus *Sigaratus*.

The foot of the animals belonging to this family, or rather of the species which constitutes the type, is oval, with a duplicature in front. The cloak is broad, with an indentation on the left side, in front, leading to the branchial cavity. A ring of transverse muscles unites the cloak with the foot. On the back is placed the shell, which does not appear on the outside, as it is covered by a thick cuticle. It is lodged in a sack, and united by a muscle, which adheres to the pillar. The hood is produced, at each side, into a flattened tentaculum, with an eye at the external base. The anus is situated at the branchial indentation on the left side. The penis is situated on the right side of the neck. It is external, with a crooked blunt lateral process near its extremity.

The mouth is in the form of a short proboscis. The tongue is armed with spines, and is long and spirally folded. The salivary glands are large. The stomach is membranaceous, giving off the intestine near the cardia. The intestine makes two folds. The liver, with the testicle in the male, and the ovarium in the female, occupy the posterior part of the body, under the spire of the shell. Two species are natives of Britain.

1. *Sigaretus haliotoidea.*—The tentacula in this species are short and flat, and the foot rounded behind. It is figured imperfectly by Montagu in *Testacea Britannica*, vignette 2. fig. 6. It occurs frequently on various parts of the coast.

2. *Sigaretus tentaculatus.*—The tentacula are produced and filiform. The foot pointed behind. This species was discovered by Montagu at Kingsbridge, Devonshire, in 1809, and described and figured by him in *Linn. Trans.* vol. xi. p. 186. *tab.* xii. fig. 5 and 6.

The animals of this order were formerly valuable in an economical point of view. Many of them yield a rich dye, which was much sought after by the ancients. This was chiefly extracted from the animal of the Murex Brandaris, and was termed Purpura. But it is likewise furnished by the animals of Purpura lapillus, Scalaria clathrus, and Planorbis corneus. Since the introduction into Europe of the Cochineal insect, the use of this dye has been superseded, so that we are now in a great measure ignorant of the process which the ancients employed to extract it.

The Pectinibranchiæ, although no longer sought after as furnishing colour for enriching dress, are still in estimation as articles of food. The Periwinkle is frequently gathered by children in this country, as well as the Nerita littoralis, and eaten when boiled. The welk and buckie are likewise sought after. All these animals are extensively employed as baits for catching fish.

VI. Order Scutibranchia.

This order was instituted by Cuvier, for the reception of animals whose general form and respiratory organs are similar to the Pectinibranchiæ, but which differ, in his opinion, in so many other particulars, as to warrant their separation. They chiefly belong to the old genera, Halyotis and Patella.

The sexes are united in the same individual in such a way as not to require union with another; or, rather, the male organs are unknown. The heart is traversed by the rectum, and is furnished with two auricles. The cloak is protected on the back by a conical or subspiral shelly-shield, into which the animal is capable of withdrawing itself. The foot is destitute of a lid. The following genera have been established in this order.

1. Halyotis. The shells of the animal of this genus have frequently been described, but it is to Cuvier that we owe the most accurate details concerning the structure of their inhabitants. The foot is oval and large. The sides of the body all round are ornamented with one or more rows of simple or branched filaments. The shell is placed on the back, with the spiral part behind, and the row of holes on the left side, through which some of the filaments are protruded. The animal is attached to the shell by a single large muscle. The entry to the branchial cavity, which likewise contains the termination of the rectum and oviduct, is on the back. The gills are in two ridges, consisting of complicated branched filaments. At the entrance of the cavity, the cloak is furnished with a slit, the left margin of which rests upon the pillar of the shell. The edges of this slit are furnished with filaments, which pass through the anterior holes of the shell. The use of this singular arrangement is unknown. The branchial cavity likewise contains the viscous organ, in common with the Pectinibranchiæ.

The hood is emarginate, with a long tentaculum on each side, behind which, towards the side, is a cylindrical protuberance, bearing the eye at the top. The mouth is in the form of a short proboscis, with two corneous plates as cheeks, and a long narrow tongue extending backwards, and covered with spines. The pharynx is dilatable, with internal folds. The salivary glands are very small. The gullet is very short. The stomach is divided into two portions. The first is striated longitudinally with a glandular structure, and receives a biliary duct. The second is separated from the former by a valve, is smaller, with transverse striæ, and a double ridge. It likewise receives bile through two apertures. There is another valve at the pylorus; and the intestine, after making some turns, is surrounded by the heart. There is an auricle on each side, receiving the aërated blood from each of the gills.

The species of this genus are by no means numerous. Montfort separated those in which the marginal holes were nearly obliterated, with an internal groove and external ridge in the line of their direction, and formed them into a genus which he terms Padolles. Lamarck likewise separated those whose shells are destitute of the marginal holes, under the generic appellation Stomatia.

2. Capulus. This genus is represented by the Patella hungarica. The foot is complicated on its anterior margin. The shell adheres to the animal by a circular muscle, leaving an opening in front, for the issue of the head and entrance to the branchial cavity. The gills form a single ridge across the roof. The mouth is in the form of an extended proboscis, with a deep groove above. The tentacula, which are two in number, have the eyes at the external base. The anus is on the right side of the branchial cavity.

We possess two species of this genus in our seas, Hungarica and Antiquata, to which M. Cuvier is disposed to add the Bulla velutina of Muller. This last shell, however, we have already noticed as belonging to the Pectinibranchiæ.

3. Fissurella.—The animals of this genus have the foot like the preceding, and the back is protected by a conical shell perforated at the apex. The shell is united to the cloak by a circular muscle, open in front. The cloak forms a duplicature in front for the branchial cavity, which extends to the perforated apex of the shell. The gills consist of two ridges; at the dorsal extremity of which is the anus. It is probable that the excrements are ejected at the perforation in the apex of the shell, and likewise the water which enters the branchial cavity in front. The head is furnished with two tentacula, bearing the eyes at the external base.

The Patella græca and apertura may be quoted as British examples of the genus.

4. Emarginula.—This genus differs from the former

in the apex of the shell not being perforated. Its place, however, is supplied by a slit on the anterior margin, the entrance to the branchiæ and anus. The foot is surrounded with a row of filaments, and the eyes are supported on short foot-stalks, characters in which it approaches the genus Halyotis. The Patella fissura of conchologists is considered as the type of the genus.

5. Crepidula.—The shell of this genus is conical, with the apex obliquely directed to the right side behind. From the hinder part of the cavity there is a thin plate or horizontal projection, which serves as a support to the abdomen. The gills form a transverse ridge on the roof of the cavity. They consist of simple filaments, which extend considerably beyond the margin of the cavity. The eyes are placed on the head, at the base of the tentacula. The Patella fornicata is the type of the genus.

6. Navicella.—The shell in this genus differs from the former in the apex being mesial, and the horizontal plate smaller. The abdominal sack likewise contains a loose, irregular, angular, testaceous body, a character of which there is no other example among the gasteropoda. The species appear to be fluviatile, living in the rivers of warm countries. The Patella neritoidea is the type of the genus.

7. Calyptrea.—The animal of this genus is not known. But the characters of the shell are well marked. It is conical, with a spiral lamina descending from the apex in the interior, marking the commencement of a pillar. The Patella chinensis of British writers may be quoted as an example of the genus.

8. Carinaria.—This genus was instituted by Lamarck, for the reception of the shell termed Argonauta vitrea. The animal has hitherto been imperfectly examined. The foot appears to be compressed, and formed for swimming. The head is covered with a group of tubercles. The mouth is furnished with a proboscis. Near the middle of the body, the shell is attached. The surface of the body above is closely covered with small tubercles. It is probable that the species here alluded to is the same with the Pterotrachea coronata of Foraskæl.

Although these genera have been constituted into a separate order, it is probable that in a natural arrangement they might more conveniently be placed with the Pectinibranchiæ. The position of the heart is indeed singular; but as this organ varies greatly in its form and position in different genera, the characters which it furnishes are, consequently, of doubtful value. The nature of their hermaphroditism has never been satisfactorily investigated.

IV. Class.—CONCHIFERA.

The molluscous animals which are destitute of a head, were separated at an early period, by Cuvier, into a distinct order, to which he gave the name of Acephala. Subsequent observations having pointed out the character of being acephalous, as common to animals which differ widely from one another in the arrangement and disposition of their other organs, it became necessary to introduce into the system a more definite method of arrangement. Accordingly, Lamarck, in his "*Histoire Naturelle des Animaux sans Vertebres*," v. p. 411, instituted the class Conchifera, which includes nearly all the inhabitants of the bivalve testacea, or those whose gills are in the form of leaves, four in number, and disposed in pairs externally, on each side the abdomen, and within the cloak. As the bivalve shells were long known to naturalists under the denomination Conchæ, the propriety of the term to designate the class, employed by Lamarck, is sufficiently obvious.

The common integuments of the Conchifera, consist of the cloak and shell. The cloak forms two leaves, one on each side the body of the animal, united behind. This cloak is, in some families, open in front, while in others, it is united; perforated, however, by holes, or tubular elongations, termed syphons, for admitting water and food. Corresponding with the two sides of the cloak, are the two valves of the shell. These valves are likewise united behind with an elastic ligament, which aids the animal in opening and shutting them. The shells are attached to the animal by the anterior margin of the cloak, which adheres to the margin of the shell, and by the adductor muscle. This muscle, which passes across the body from one valve to another, brings the valves, by its contractions, into contact, at their free edges, at the same time that the ligament is compressed or stretched, according as it is internal or external. When the muscle is relaxed, the ligament exerts its power, and opens the valves; and along with the valves, the cloak to which they are attached. The adductor muscle is in some families divided, and the two portions separated from each other.

Locomotion is performed in some to a limited extent, by suddenly opening and shutting the valves. In general, however, those species which shift their place are furnished with a muscular projection from the body, capable of changing its shape, and attaching itself to foreign bodies, termed a foot. The base of the foot is usually attached by two or more tendinous filaments to the shell. The *byssus* issues from a muscular body, likewise connected by filaments with the shell, and is fixed to other bodies. The foot is supposed to be the organ which spins this thread; but its mode of formation is involved in obscurity. While some are permanently fixed, and others are capable of moving from one place to another, there are a few which prefer a residence in different substances in which they have excavated a habitation. These last are termed *Borers*. It was supposed by many that the animal secreted a liquor, with which it dissolved the bodies into which it penetrated; but the sagacious Reaumur soon ascertained that the boring was performed by means of a rotatory movement of the larger valves. M. Fleurieu Bellevue states, that the calcareous stone, in which the Rupellaria lithophaga is found, is often discoloured in the immediate neighbourhood of its recess. This may arise from the secretions of the animal, or even from the stagnant sea water in the hole, and not from the action of the phosphoric acid, or any other solvent supposed to be employed by the animal. These solvents would act equally on the shell as on the calcareous rock. But the borers are not confined to calcareous rocks: they also lodge in slate-clay, and other argillaceous strata. This is very often the case with the Pholades. But this character can never be extensively employed in the distribution of genera, as the same species which, at one time, may be found imbedded in stone, will be observed, at another, seated among the roots of sea-weed, or buried among gravel.

The nervous system is here more simple than in the animals of the preceding classes. There are no ganglia scattered through the body; all the nervous filaments taking their rise either from the medullary mass above the entrance to the stomach, or from the one beneath. Although the body does not appear liberally supplied with nerves, yet the sense of touch is exquisite, particularly in those filaments or tentacula with which the margin of the cloak, or its apertures, are provided. No organs of sight or hearing have been observed.

The food of the Conchifera appears to be obtained exclusively from the substances floating or mixed with the water. These are brought within the sphere of the mouth by the movements of the cloak. The mouth itself is destitute of proboscis, jaws, tongue, or even lips. Around its margin are four tentacula, which, in structure, bear a considerable resemblance to the branchia. The mouth opens immediately into the stomach, without the intervention of any thing which can be called a gullet. This organ is usually full of cells; the bottom of each pierced with a biliary duct. The liver surrounds the stomach, and empties its bile by numerous openings. A singular *crystalline process*, cylindrical, cartilaginous, and transparent, projects into the cavity of the stomach, whose use has not been determined. There is sometimes an enlargement, in the form of a second stomach. The intestine, in some species, makes several convolutions; in others, particularly those which are fixed, it is remarkably short. The anus is placed in the extremity of the body, opposite to the mouth, and either opens into the cavity of the cloak, or into one of its syphons.

The only organ of reproduction hitherto observed in this class, is the ovarium. This occupies the sides of the body, and penetrates the membranes of the cloak. The eggs pass into the gills, where they are hatched, and, bursting the integuments, make their escape. In the ovarium has been observed, at certain seasons, a milky fluid, regarded as *sperm*. There appears to be no reason to infer the existence of any thing like sexual union. Lamarck is supposed to consider fecundation as effected by means of an impregnating fluid mixed with the water, which must therefore have been ejected from male organs. This supposition, however, is neither supported by facts nor analogy.

The most important of the peculiar secretions of the animals of this class, is the Pearl. This substance, equally prized by the savage and the citizen, is composed, like shells, of carbonate of lime, united with a small portion of animal matter. Pearls appear to be exclusively the production of the bivalve testacea. Among these, all the shells having a mother-of-pearl inside, produce them occasionally. But there are a few species which yield them in the greatest plenty, and of the finest colour. The most remarkable of these is the *Avicula margaritifera*. This shell, which was placed by Linnæus among the mussels, is very widely distributed in the Indian Seas; and it is from it and another species of the same genus, termed *Avicula hirundo*, found in the European seas, that the pearls of commerce are procured. The *Pinna*, so famous for furnishing a byssus or kind of thread, with which garments can be manufactured, likewise produces pearls of considerable size. They have seldom the silvery whiteness of the pearls from the Avicula, being usually tinged with brown. But the shell which in Britain produces the finest pearls, is the *Unio margaritifera*, which was placed by Linnæus in the genus *Mya*. It is found in all our alpine rivers. The Conway and the Irt in England, the rivers of Tyrone and Donegal in Ireland, and the Tay and the Ythan in Scotland, have long been famous for the production of pearls. These concretions are found between the membranes of the cloak of the animal, as in the Avicula, or adhering to the inside of the shell, as in the Unio. In the former case, they seem to be a morbid secretion of testaceous matter; in the latter, the matter appears to be accumulated against the internal opening of some hole, with which the shell has been pierced by some of its foes. Linnæus, from the consideration of this circumstance, endeavoured, by piercing the shell, to excite the animal to secrete pearl; but his attempts, though they procured him a place among the Swedish nobility, and a pecuniary reward, were finally abandoned; the process being found too tedious and uncertain to be of any public utility. The largest pearl of which we have any notice, is one which came from Panama, and was presented to Philip II. of Spain, in 1579. It was of the size of a pigeon's egg. Sir Robert Sibbald mentions his having seen pearls from the rivers of Scotland as large as a bean.

All the animals of this class inhabit the waters. A few species live in pools, lakes, and rivers, preferring fresh water; but the sea contains the greatest numbers.

The following arrangement of the genera is the one adopted by M. Cuvier in his "*Règne Animal.*" As it stands at present, it brings together into groups nearly allied genera, without, however, distributing them, with much accuracy, into natural families.

Section I.

In the Conchifera which are brought together in this section, the cloak is open, and the water comes directly in contact with the gills and mouth. The foot, when it exists, is very small; and, instead of aiding locomotion, appears to be principally employed in forming and fixing the threads of the byssus. Many of the species are cemented to the rocks from infancy to old age, others are capable only of shifting to a short distance, by violent exertions, consisting in suddenly opening and shutting their valves.

I. Tribe.—The animals of this tribe is distinguished by possessing only one adductor muscle for closing the valves of the shells, which are inequivalve. The distribution of the genera into natural families, is at present impracticable, as the animals of few of the species have been investigated with any degree of care.

In the genus Ostrea, represented by the common oyster, the abdomen is prominent, the adductor muscle central, and the branchiæ united at their summits with the edge of the cloak. The animals of the genera Acardo and Gryphœa, are unknown.

In the animals of the genus Pecten, represented by the common scallop, there is a small foot, supported on a short stalk arising from the abdomen. The margin of the cloak is surrounded with two rows of tentacula, some of which, in the external row, have greenish tuberculated summits. The mouth is surrounded with numerous branched tentacula, in place of the four ordinary labial appendages. The genera Lima and Pedum are nearly related to the genus Pecten, with which they constitute a particular family.

The genus Anomia, as now restricted, is distinguished by the singular character of the adductor muscle, a portion of which is attached to the corneous or testaceous plate, which passes through the cardinal perforation, and adheres to rocks. There is a small foot, which is capable of being likewise protruded through the cardinal perforation.

In the genus Spondylus, the margin of the cloak is fringed with a double row of tentacula, with tuberculated summits, and the foot is seated on a short stalk, with a large radiated disk.

Besides the genera already noticed, the Placuna, Plicatula, Malleus, Vulsella, and Perna, likewise belong to this tribe. Many of the species are eagerly sought after as food, as the oyster and scallop, and give employment to several thousands of the inhabitants of this country, in fishing, and conveying them to the market.

In the revolutions which molluscous animals have undergone, the genera of this tribe appear to have suffered greatly. Multitudes of extinct species, and even genera, are to be found in the solid strata, differing in shape and size from those which are now found in our seas. We are disposed to refer to this extinction of genera, as accounting for the circumstance, that in this tribe almost every genus stands apart, and appears to be but remotely connected with those with which it is now associated, the connecting links having been destroyed.

II. Tribe.—The valves in this tribe are moved by means of two adductor muscles, one of which is placed near the head, and the other at the anus of the animal.

The pearls produced by the animals of the genus Avicula have been long known, and highly prized; but their anatomy and physiology are still involved in obscurity. The *A.* hirundo has been determined by Mr. Sowerby to be a native of the British seas, he having obtained specimens both from Marazion and Bantry Bay. In the genus Crenatula of Lamarck, which is intimately connected with the preceding, there is no mark indicating the animal to have a byssus, which the Avicula is known to possess.

The genus Pinna has been long known and highly prized by collectors. The mouth of the animal is situated near the narrow end of the shell. Near the anus there is a conical appendage, susceptible of enlargement and contraction, whose use is unknown. The thread or byssus with which the animal adheres to the sand in which it resides, is collected on the Neapolitan coast; and when mixed with silk, is woven into various articles of dress, as gloves and stockings.

The genera Arca, Pectunculus, and Nucula, form a family formerly included in the genus Arca of Linnæus. The animals of the genus Arca have a pedal ligament, with which they adhere to different bodies. The animal of the Pectunculus, on the other hand, is furnished with a large compressed foot, with which it is able to crawl. The inhabitant of Nucula is unknown.

Section II.

The animals of this section have two adductor muscles. The cloak is open in front, with a separate aperture behind, for the passage of the excrements. The shells are equivalve. The species were formerly included in the genus Mytilus.

In the restricted genus *Mytilus*, represented by the common mussel, the beak is terminal. The margin of the cloak, at the rounded angle of the front of the shell, is fringed with branched tentacula. In the genus *Modiolus*, represented by the Mytilus modiolus of Linnæus, the beak is removed a little way from the anterior extremity. In the *Lithodomus* of Cuvier, which includes *Mytilus lithophagus*, both extremities of the shell are equally rounded, whereas in the Mytilus and Modiolus, the anterior is the most pointed. In these three genera there is a foot and byssus.

The genera *Anodonta* and *Unio* are inhabitants of fresh water, resembling each other in the form of the animal, but differing in the structure of the hinge of the shell, the former being destitute of the teeth possessed by the latter. The foot is large and compressed. The posterior end of the cloak is fringed with small tentacula. The Anodonta is represented by *Mytilus anatinus*, and Unio by *Mya margaritifera* of Linnæus. M. Cuvier considers the genera Cardita, Venericardia, and Crassatella, as nearly allied to the genera of this section.

Section III.

This section includes at present only two genera, Tridactina and Hippopus. The cloak is furnished with three openings, all of them near the anterior extremity. The first of these is the largest, and serves for the passage of the byssus. The second admits the water to the branchiæ, and the third is opposite the anus. The valves are closed by one adductor muscle.

Section IV.

The animals of this section resemble those of the last in the three apertures to the cloak. The first is large, and the two last are sometimes produced into separate or united tribes. The foot issues from the anterior opening, while the two posterior apertures serve for respiration and the passage of the excrement. There are two adductor muscles for closing the shell, one near the mouth, and the other at the anus.

In the genus *Chama*, the two posterior apertures are in the form of short tubes, the anterior one is small, and indicates the corresponding size of the foot. The foot of the animals of the *Isocardia* is much larger, and the anterior aperture is large in proportion.

In the common cockle (Cardium,) prized by many as an agreeable article of food, the foot occupies a large share of the cavity of the shell. It is bent in the middle, with the point directed forwards. Cockles are considered in season during March, April, and May. They are sold in this country by measure, and eaten either raw, or boiled and pickled.

In the genera Cyclas, Tellena, Donax, and Venus, the foot is long and tongue-shaped, and the posterior tubes, in general, considerably produced, and more or less united at the base. In the genus Loripes, the foot is small and cylindrical, and the tubes short and united. In the Mactra the tubes are likewise short, but the foot is compressed.

Section V.

In the animals of this section the cloak is united in front, with an opening at the anterior extremity for the passage of the foot, and a production at the other extremity in the form of two united tubes. The cuticle of the cloak is continuous with that which invests the shell. Hence, when the animal is removed, the cuticle frequently remains on the margin of the valves in loose membranes.

The animals of the different genera are constructed nearly on the same plan, so that it is impossible, without the aid of the shell, to give them any definite arrangement. The following genera are considered as belonging to this section: Mya, Lutraria Anatina, Glycymeris, Panopea, Pandora, Gastrochæna, Byssomia, Hiatella, Solen, Sanguinolaria Pholas, Teredo and Fistularia. They all appear to prefer concealment, lodging in the sand, in stones or wood. Many of them are used as food, as the Razor-fish (Solen,) and Gapers (Mya.)

Class V.—TUNICATA.

This class was first instituted by Lamarck in the year 1816, and has now been generally adopted by naturalists. It includes the "Acephales sans coquilles" of the system of M. Cuvier, and embraces several of the zoophytes as well as mollusca of the system of Linnæus.

The animals of this class are all naked, the external covering being soft and coriaceous. There are two apertures, one for the use of the gills in respiration, and the other for the digestive organs. These apertures are frequently surrounded with productions in the form of tentacula. The inner cloak is in many genera loose, in others adhering, but in all it is united with the external one at the two apertures. These sacs are furnished with muscular bands and filaments; and traces of a nervous system have been perceived. The alimentary canal is very simple, and scarcely can be distinguished into gullet, stomach, and intestine. The liver adheres to the stomach, and in many is divided into distinct lobes. The gills cover the walls of the cavity of the inner tunic. They are in the form of ridges more or less complicated. The circulating system appears to be reduced to a single systemic ventricle. The organs of reproduction consist of an ovarium, either simple or complicated, with some additional glands, whose uses are not ascertained.

All the animals of this class live in the sea, and are very widely distributed. Some of them are fixed to rocks and sea-weeds, others move about in the water. Many genera possess species whose individuals are detached and independent, while with others there is an inseparable union. These united individuals constitute a symmetrical mass, in some cases capable of moving about in the surrounding element.

The investigation of the structure of this class of animals has been conducted with great care and success by M. Savigny, in his "*Recherches anatomiques sur les Ascidies composées et sur les Ascidies simples*," inserted in his "*Mémoires sur les Animaux sans Vertèbres*." Paris, 1816. MM. Desmaret and Lesueur have likewise contributed materially to unfold their structure. The labours of these authors, together with Cuvier's papers on the genera Salpa and Ascidia, embrace nearly all the information which has been obtained regarding the structure and physiology of the animals which have been brought together in this class. It is our intention to give a brief exposition of the systematical characters of genera, according to the method followed by M. Savigny.

Subdivision I. Tethydes.

In this subdivision the inner tunic is detached from the external covering, except at the two orifices. The branchiæ are large, unequal, and cover the walls of the great cavity. The opening to this cavity is surrounded on the inside with a membranaceous, denticulated ring, or with a circle of filaments.

Order I.

The animals of this Order are all fixed to other bodies, without the power of displacing themselves. The branchial and anal openings are neither opposite, nor do they communicate directly with each other. The branchial cavity is open at its upper extremity only, and the aperture is fringed with tentacula; the gills of both sides are continuous. The genera are distributed into two sections.

Section I.

This contains the animals formerly included in the genus Ascidia of Linnæus. They are distinguished by the separate or independent existence of the different individuals. In some species many individuals adhere to the rock in clusters, and appear to constitute one animal; but these can be easily separated, as they possess no common covering or organical connection. The genera of this section are four in number, and are distributed into two families. In the first family the orifices are furnished with four rays, and the genera are *Boltenia* and *Cynthia*, the former represented by the Ascidia pedunculata, having the body supported on a stem, while in the latter the body is sessile, as in C. conchilega, a native of the British seas.

In the second family, the anal and branchial openings are either destitute of rays, or they exceed four in number. The genera are two. In the *Phallusia* the body is sessile. The branchial orifice usually possesses eight rays, and the anal one six. The P. *mentula* is very common on rocks and old oysters in the British seas. The P. *intestinalis* and *prunum* are likewise natives. In the genus *Clavelina* the body is pedunculated, and the apertures are destitute of rays. The C. *lepadiformis* has been added to the British Fauna by the industry of Dr. Leach. The genus Mammaria of Muller will probably constitute a third family in this section, when its structure has been determined. The body is smooth, having the base fixed to sea-weeds, and the summit perforated by a single aperture. One species, the M. mammilla, inhabits the British seas, having been observed at Leith by Professor Jameson, and at Belfast by Mr. Templeton. The genus Bipapillaria of Lamarck is involved in equal obscurity.

Section II.

In this section are included animals which were formerly placed among the zoophytes, and chiefly in the genus *Alcyonium*. They are compound animals, many individuals being united under a common covering. They admit of division into three families.

In the first family the branchial and anal orifices have six rays each. The genera of this family are three in number. The *Diazona* is distinguished by the body being sessile, orbicular, and consisting of a single system or group of individuals. The D. *violacea* of Savigny is the only known species. In the *Distoma* the body is sessile and polymorphous, and the individuals are arranged in systems or groups. The D. variolosus, first observed by Gartner, is a native of our seas, and is the Alcyonium ascidioides of Pallas. In the *Sigillina*, the body is conical and pedunculated, consisting of a single group of individuals. The S. australis of Savigny is the only known species.

In the second family the branchial orifice only has six regular rays. The genus *Synoicum* has the body cylindrical, vertical, and pedunculated with a single system. The S. turgens of Phipps, a native of the Arctic seas, is the only species which has been described. In the month of August 1817, we observed a Synoicum, adhering to a rock in the sea at the Isle of May. It differed from the *turgens*, as described by Savigny, chiefly in the smoothness of the skin. In the *Sydneum* the body is inversely conical, vertical, pedunculated, with a single system. The S. turbinatum, observed by Dr. Leach as a native, is the only known species of the genus. In the genus *Alpidium*, the body is variously shaped, sessile, consisting of many systems, which are destitute of a central cavity. The *A. ficus*, or Alcyonium pulmonaria of Ellis's zoophytes, belongs to this genus. In the *Polyclinum* the body is likewise sessile, but the individuals are in systems with central cavities. The *Didemnum* is sessile, spongy, and incrusts other bodies. The anal opening is obscure.

In the third family, both the branchial and anal orifices are destitute of rays. The body invests fuci and rocks, and consists of several systems. In the genus *Eucœlium*, the systems are destitute of central cavities. In the genus *Botryllus*, on the other hand, there is a central cavity to each system. The last genus contains the following British species: B. *Leachii, Borlassii, Scholosseri*, and *Conglomeratus*.

Order II.

The animals which remain to be considered, as constituting this order, are free, and float about in the water. Many individuals are united, forming a conical bag. The anal and branchial openings are diametrically opposite to each other. The branchial cavity is open at both ends, the anterior aperture is destitute of tentacula, but furnished with a denticulated ring. The branchiæ are disjoined. There is only one genus in this order known, which has been termed *Pyrosoma*. It contains the following species, *verticillata*, *paniculata*, and *atlanticum*.

Subdivision II.—Thallides.

This subdivision embraces animals whose inner tunic adheres to the external one at all points; whose branchial orifice is furnished with a valve; and whose branchiæ consist of two united narrow leaves.

The animals here referred to were first formed into a separate genus by Brown, in his *History of Jamaica*, under the title Thalia, a name now usurped by Flora. Forskael afterwards instituted his genus Salpa, and Sir Joseph Banks the Dagysa, for the reception of similar animals. The name of Forskael has been preferred by naturalists. Few of the species have been examined in a recent state. They appear to be numerous, and to exhibit a considerable variety of character; perhaps sufficient to warrant their distribution into several distinct genera. They appear to inhabit chiefly the seas of warm climates.

Class VI.—BRACHIOPODA.

This class was instituted by M. Cuvier, in consequence of an examination of the animal of the Patella unguis of Linnæus. Its characters are well marked, and abundantly justify the propriety of the change. The animals of this class are acephalous; and, like the conchifera, have the cloak divided into two lobes, protected by a bivalve shell. These lobes are free at the anterior margin. The branchiæ consist of small leaves, arranged along the inside of the edge of the cloak, and intimately united with it. From the body, between the lobes of the cloak, issue two arms, fringed with filaments. These are capable of folding up in a spiral form. The mouth is situated between the arms at the base.

All the animals of this class are inhabitants of the sea, and they are permanently attached to rocks and stones. Three genera are known, which are probably the types of as many orders.

1. *Lingula*. The valves of the shell of the species which constitutes this genus were first figured by Seba, together with the peduncle by which they are supported. Linnæus, having seen only one valve, conjectured that it belonged to the Patella, and named it P. unguis. Chemnitz examined both valves, without the peduncle, and pronounced them connected with the genus Pinna. Bugiere, aware of Seba's figure, contemplated the formation of the new genus for its reception, which Lamarck executed. M. Cuvier afterwards dissected one of the individuals which Seba had possessed, and unfolded characters in its organization, sufficient not only to warrant the construction of a new genus, but a new class.

The peduncle of the Lingula is cartilaginous, having the inferior ends of the two oval valves attached to its extremity, the other end being fixed to foreign bodies. The valves are destitute of teeth, or an elastic ligament, and are opened chiefly by the arms when pushed out, and closed by the adductor muscles, which are capable of acting in an oblique direction, and of giving to the valves a considerable degree of lateral motion. The margin of the cloak, which is double like the shell, is fringed with fine hairs. The arms are fleshy in their substance, conical, elongated, and compressed in their form, and ornamented on the external surface with thickset fringes or tentacula. The mouth is situated between the arms at their base, and is simple. There is no enlargement of the alimentary canal, which can be regarded as a stomach, and the anus is a simple aperture, situated on the side. There are marked indications of salivary glands and a liver. The blood is conveyed to the gills by two vessels, which are divided at the separation of the lobes into two branches, one of these going to the half of one lobe, and another to the opposite half of the other lobe. Two systemic veins occupy a similar position, and return the aërated blood to the two lateral systemic ventricles. The gills themselves are arranged in a pectinated form on the inner surface of each lobe of the cloak. There is nothing known of the nervous or reproductive systems of this animal.

The Lingula unguis is the only species of the genus, and appears to be confined to the Indian seas. Some petrifactions have recently been referred to this genus; but in the absence of all vestige of the peduncle, we do not consider the mere form of the shell as furnishing characters sufficiently obvious and precise to warrant such arrangement.

2. *Terebratula*. The muscular peduncle of this genus passes through a perforation in the largest valve. The arms are shorter than those of lingula, and forked at the extremities. They are supported within by numerous arcuated plates.

There is one recent species described in the article Conchology, vol. vii. p. 36, genus xxxix. and figured tab. ccvi. fig. 2, as *T. vitrea*. It appears, however, to be the *T. cranium* of Muller, figured in *Zoologia Danica*, tab. xciv. f. 1. Although we can boast of only one recent species of this genus, our rocks abound in many others which are extinct. Mr. Sowerby, in his valuable work, *Mineral Conchology*, now publishing, has given excellent representations of several of these. He has been able, from an attentive examination of their form, to construct several new genera, and, from a dissection of the cavity, to unfold the remains of the spiral arms.

3. *Criopus*. In this genus, first instituted by Poli, one of the valves is membranaceous and flat, and adheres to stones, and the other is flatly conical, and resembles a Patella. The arms nearly resemble those of Lingula. The ovarium, according to Muller, is double and branched, and the eggs are round.

The *Criopus anomalus* is described and figured by Muller under the name Patella anomala, in the *Zoologia Danica*, tab. v. f. 1—8, and by us, for the first time, as a native of Britain, in the article Conchology, vol. vii. p. 65, genus i. sp. 7, P. distorta, tab. cciv. fig. 4.

It is to be regretted, that so little progress has been made in the examination of the animals of this class. We are still ignorant of their nervous system, and their mode of propagation; and when these and their other organs shall be more carefully investigated, many new divisions will probably be necessary, as the species increase in number.

Class VII.—CIRRHIPODA.

The genus Lepas of the Linnean system, after having been subdivided into different genera, has at length, by the efforts of M. Lamarck, been formed into a distinct class. The animals which it includes are protected by a cloak, strengthened by testaceous plates, to which the body adheres by one or more muscles. The head consists of a slight eminence attached to the anterior portion of the body, and, when in the natural position, near the inferior margin. The body is followed by a tail, supporting six feet on both sides, each of which consists of a short stem, which divides into two tapering jointed fringed filaments; these, by their motion towards the mouth, bring the water and its contents within the sphere of that organ. The tail terminates in a conical tubular body, which has improperly been termed a proboscis.

The nervous system consists of a cord encircling the gullet, and giving out filaments to the mouth; its two ends running along the belly and tail, and uniting at the base of each pair of feet to form a ganglion, and give off filaments.

The mouth is furnished with an obvious upper lip, a pair of maxillæ on each side, with the rudiments of palpi. Ellis says, "the mouth appears like that of a contracted purse, and is placed in front between the fore claws. In the folds of this membranous substance are six or eight horny laminæ, or teeth, standing erect, each having a tendon proper to direct its own motion. Some of these teeth are serrated, others have tufts of sharp hairs instead of indentations on the convex side, that point down into the mouth; so that no animalcule that becomes their prey can escape back." The gullet is very short, and enters into a stomach, having two cæca and glandular walls, which serve as a liver. The intestine is short and simple, and terminates behind at the base of the caudal appendage. There are two salivary glands attached to the stomach. The gills are conical bodies, situated at the base of the feet. The organs of circulation are imperfectly understood. Poli observed the motion of the heart, but the vessels which are connected with it are unknown.

The organs of reproduction appear, according to Cuvier, to consist of an ovarium giving out an oviduct, which traverses a body considered as a testicle, and both the canals unite in a common tube, which traverses the caudal appendage, and opens by a small pore at its extremity. This aperture Cuvier regards as simple, but Ellis observes of the whole, "it is of a tubular figure, transparent, composed of rings lessening gradually to the extremity, where it is surrounded with a circle of small bristles, which likewise are moveable at the will of the animal. These, with other small hairs on the trunk, disappear when it dies." There is probably no union of individuals, each being perfect hermaphrodites.

The rapidity of growth which these animals exhibit is truly astonishing. A ship's bottom becomes covered with them in a few months, and the spawn of some kinds deposited on a feather, as stated in the memoirs of the Wernerian Society, vol. ii. p. 243, will become unfolded, and attain maturity before the feather exhibits any symptoms of decay.

The animals of this class are all inhabitants of the sea, and are all fixed to other bodies. Many of them, however, are attached to floating wood, and others to the skin of marine animals, so that they enjoy all the advantagers of locomotion without the exercise of the exertion requisite for its production. Their remains are seldom found in a fossil state. Some of the species have been used as food. In taking a view of the genera we shall distribute them, as formerly, after the manner of Ellis, *Phil. Trans.* vol. l. p. 848, into pedunculated and sessile.

Order I. Pedunculated.

The essential character of this order consists in the body being supported by a peduncle, the lower part of which is permanently fixed to other bodies.

The cloak consists of three membranes. The external one is the cuticle, and invests the whole external surface of the animal. Underneath this is the true skin, in which are formed the testaceous plates that protect the body. These plates or valves are evidently formed in the same manner as common shell, the layers of growth being indicated by the striæ on the surface. The inner membrane forms a sac for the body itself. This bag is closed on all sides except opposite to the tail, where there is a slit, through which the feet are protruded.

The peduncle consists of the two external membranes of the integuments of the body. The cuticle covers its surface, and even the base by which it adheres. The true skin is covered on its central aspect with numerous muscular threads. The summit of the peduncle next the body is covered with the inner membrane of the cloak, through which, however, there is a perforation, corresponding to a large vessel which descends along one of the sides of its central cavity. This cavity, in the *Lepas anatifera*, Cuvier found filled with a white cellular substance soaked with muscus. Ellis, on the other hand, found the peduncle of what has usually been regarded as the L. aurita "full of a soft spongy yellow substance, which appeared, when magnified, to consist of regular oval figures, connected together by many small fibres, and no doubt are the spawn of this animal." This view of the subject entertained by Ellis may, upon investigation, lead to the conclusion, that the cavity of the peduncle and its lateral vessel are connect with the reproductive organs. It would be desirable to have the branched peduncles dissected with care, as a knowledge of their structure might throw some light on the mode of growth of these animals.

1. *Family.* This group is characterized by the body being protected by five testaceous plates, and by the peduncle being naked. It includes the following genera.

1. *Lepas.* The two lateral plates at the summit of the shell are very large, nearly covering the whole of the compressed body, and having attached to it the large adductor muscle. The two valves which protect the sides of the tail are much smaller, and somewhat triangular, while the dorsal one is narrow and convex externally. The branchiæ are four in number, two on each side of the body, near the origin of the first pair of feet. The British species are four in number, *L. anatifera*, *anserifera*, *sulcata*, and *fascicularis*.

2. *Otion.* This genus was instituted by our zealous and intelligent friend Dr. Leach, whose labours have greatly contributed to improve the classification of the genera of this class. The body is but slightly compressed, and the valves are very small and distant from one another, the body being chiefly covered by its membranaceous cloak. The inferior part of the cloak terminates in two tubular appendages, through which the water escapes which has been taken in at the oral aperture, and has passed along the surface of the gills. The gills are sixteen in number, eight on each side. The first pair on each side resembles those of the Lepas, the remaining six are attached to the base of the feet. There are two British species. 1. *O. aurita*, Cuvier, *Mem. des Anatifes.* Fig. 12, 13. A specimen of this was found on the Dawlish coast, Devon, by Mr. Comyns. 2. *O. cornuta*, taken alive from the bottom of a transport stranded on the coast of Devon, by Montagu, and described and figured by him, *Linn. Trans.* vol. xi. p. 179, tab. xii. f. 1.

3. *Cineras.* This genus was likewise instituted by Dr. Leach. The valves are equally minute and remote as in the preceding genus, but there is here no appearance of tubular appendages to the cloak. The *C. membranacea*, first described and figured by Montagu, *Linn. Trans.* vol. xi. p. 182, tab. xii. f. 2. is the only species known to inhabit the British seas.

2. *Family.* In this family the testaceous valves are numerous, greatly exceeding five. It consists of two genera.

1. *Scalpellum.* The testaceous valves are thirteen in number, and invest the body. The peduncle is covered with corneous wrinkles, having hairy interstices. The S. vulgare, the *Lepas scalpellum* of British authors, is the type of the genus.

2. *Pollicipes.* The testaceous valves are ten in number, with numerous scales investing the base of the peduncle near the body. The *P. vulgaris*, or *Lepas pollicepis*, is the type of the genus.

II. Order. Sessile.

In this order the body adheres directly to foreign substances, without the intervention of a tubular stalk. The adhesion is effected in some by the coriaceous cloak, in others by a layer of testaceous matter. The testaceous covering usually assumes a conical form, the base being attached to rocks or other substances, and the apex truncated and open, as an entrance for the water. This cone consists of six valves, closely connected together, but capable of being disjoined by maceration, especially when young. In old shells, where the valves have attained their full growth, they appear to become cemented together, so that it is very difficult to effect their separation. The valves are so arranged, that one protects the belly, another the back, and two on each side the lateral parts. In some genera, all these valves are so united, that the lines of separation are not perceptible, while in others the double lateral valves only are incorporated. Each valve consists of an elevated and depressed portion. The elevated portion is conical, with its base at the adhering part of the shell, while the depressed part of the same form has the base at the mouth. The former consists of conical vertical tubuli, while the latter appears solid. When the base is testaceous, it is either solid, or consists of horizontal tubuli, radiating from a centre united by a simple layer, exhibiting concentric circles.

The structure of the valves gives sufficient indications of the manner in which they are formed. M. Dufresne, in a paper published in the *Annales du Museum* 1. p. 465, advanced the singular opinion, that the animals quitted their old shells when they became too small, and formed new ones suited to their size. The arguments by which it is supported indicate an ignorance of the structure of the shell, and the relations of the parts of which it consists. To us it appears plain, that each valve is increased in two directions, the elevated part by an extension of the tubuli at the base, and the depressed part by the application of fresh matter to the side. The striæ, which are the indications of successive depositions of matter, and the structure of the valves themselves, point out this mode of enlargement as the only one which can take place, even on the supposition that the shell is frequently renewed. By the growth of the elevated parts, the shell increases in height and diameter at the base, while the growth of the depressed parts preserves to the mouth suitable dimensions for the corresponding increase of size in the parts of the operculum. It is obvious that this increase of diameter at the base must be accompanied by a corresponding enlargement of its covering. This takes place by the extension of the horizontal tubuli, and each enlargement is marked by a concentric ridge.

This opinion which we have espoused, and which we find hinted at by Lamarck, in his "*Histoire Naturelle des Animaux sans Vertebres*," v. p. 398, is founded on the structure of the different valves, the indications of the layers of growth, and the manner in which the valves are separable from each other and from the base. We might have entertained some suspicions of error, had we not attended to the morbid appearances of the shell, the restraints imposed on its growth by the situation in which it lives, but especially the manner in which fractures are healed, and abstracted parts restored by the secretion of new matter. Such observations have removed all suspicion, and demonstrated the truth of the explanation offered. It may be added, however, that, in the case of the inversely conical shells, the increase probably takes place at the mouth.

The mouth of the shell is closed by the cloak of the animal, leaving in the centre a tubular or linear aperture for the protrusion of the feet and entrance of the water. This part of the cloak is protected by testaceous plates, which, by their union, form a lid to the mouth of the shell, for the protection of the contained inhabitant. The valves of the lid are four in number, two on each side the mesial line, or orifice. In some genera the lateral valves are united. The operculum of this order may with propriety be compared to the shelly plates of the body of the preceding order—and the shelly body of this order corresponds to their peduncle, circumstances indicated by the muscular attachments of the animal. The continued action of the valves of the lid obviously assist in wearing down and enlarging the aperture of the shell.

There is little known, either with regard to the organs of digestion or respiration, in the animals of this order. In their manner of reproduction, they appear to resemble those of the preceding order. Ellis "found the lower part of the shell, which contained a cavity equal to two-thirds of the whole, full of spawn." The genera of this order divide themselves into three families, from circumstances connected with the shell.

1. *Family*.—The shell in this family consists of six valves, and the lateral valves of the lid are divided. It contains five genera.

1. *Tubicinella*.—The form of the shell in this genus is inversely conical, the apex which constitutes the base being truncated. It consists of a series of horizontal rings, which mark the successive periods of growth, and there are six vertical grooves, which indicate the divisions of the valves. The increase of the shell with age, in this genus, probably takes place by the addition of a new ring to the mouth. The testaceous plates of the lid are all of equal size. The inferior aperture of the shell is open, or simply closed by the integuments of the cloak. The animal resides in the skin of the whale, the lower rings being inserted in the fat, while one or more of the upper ones appear above the cuticle. The T. *balænarum* is the only known species.

In the remaining genera of this family, and the others which follow, the shell is conical, its truncated apex being the mouth; and its mode of growth such as is detailed in the general remarks on the order.

2. *Coronula*. The base of the shell is open, as in the preceding genus. The valves of the lid are unequal in size, the dorsal ones being small. The animals included under this genus likewise inhabit the skin of the whale. Several species of this genus are known. The C. *diadema* holds a place in the British Fauna.

3. *Chelonobia*.—In this genus the base of the shell is likewise open, but it differs from the preceding in the plates of the lid being all of equal size. The C. *testudinaria*, a species which resides on turtles, is the type of the genus.

4. *Balanus*. The shell in this genus is closed below by a layer of shelly matter, which adheres to foreign bodies, and conforms to the inequalities of their surface. Nine species are described as natives of Britain.

5. *Acasta*. In this genus the base of the shell is cup-shaped. The species reside in sponges, in the substance of which the base and sides are imbedded. One species, the *Balanus spongiosus* of Montagu, is a native of the English seas.

2. *Family*. The valves of the shell in the genera of this family are only four in number.

1. *Creusia*.—The base in this genus is funnel-shaped. The lateral valves of the lid are united. The C. *spinulosa* of Dr. Leach is the type of the genus. It is imbedded in the substance of Madrepores.

2. *Conia*.—The shelly base in this genus conforms to the substance to which it is attached. The lateral valves of the lid are separate. The C. *porosa* is the type of the genus.

3. *Clisia*.—The base of the shell is spread on the surface of the bodies to which it it attached. The lateral valves of the lid are united. The Balanus stratus of British writers is the type of the genus. An imperfect representation of the animal is given by Cordiner, in his "*Remarkable Ruins*," table, Aggregate of Corals.

3. *Family*. The shell is undivided in the only genus of this family which is known, termed *Pyrgoma*. The base is cup-shaped, and the lateral valves of the lid are separate.

Although we have introduced this class to the notice of our readers under the article Mollusca, we are nevertheless of opinion, that it is more nearly related to the annulose animals. The appearance of the nervous system, and the structure of the mouth and of the tail, intimate its connection with the crustacea, and justify the appellation *Crustacea conchilifera*, by which Lamarck intended at first that it should be designated.

We shall now conclude this article by a list of figures of a few of the species in the different classes, illustrative of the forms which they exhibit. The reader will find in Plates CCCXCVIII. and CCCXCIX. Fig 1. Ocythöe cranchii. Fig. 2. Two of the corneous rings of the suckers of Loligo sagittata. Fig. 3. Mandibles of ditto, a, the under one, b, the upper one. Fig. 4. Pneumodermon, peronii. Fig. 5. Testacella haliotoidea. Fig. 6. Onchidium typha. Fig. 7. Doris marginata. Fig. 8. Thethys fimbria. Fig. 9. Phyllidia ocellata. upper side. Fig. 10. Phyllidia trilineata, under side. Fig. 11. Pleurobranchus membranaceus. Fig. 12. Bulla hydatis. Fig. 13. Valvata cristata, magnified. Fig. 14. Buccinum undatum, without the shell. Fig. 15. Hyliotis tuberculata. Fig. 16. Modiolus vulgaris. Fig. 17. Synoicum turgens. Fig. 18. Lingula unguis. Fig. 19. Tubicinella balænarum. Fig. 20. Coronula balænaris.

(J. F.)

MOLUCCAS, or Spice Islands, comprehends, in the most extensive sense of the term, all the islands between Celebes and New Guinea, situated to the east of the Molucca passage, in longitude 126°, particularly those of Gilolo; but, in a more limited sense, it is usually restricted to the Dutch Spice Islands, Amboyna, Banda, Batchian, Ceram, Ternate, Tidore, &c. These islands (the chief of which will be found described under their respective names in this work,) were first discovered by the Portuguese in 1510, but afterwards fell into the hands of the Spaniards, who were supplanted in their turn by the Dutch in 1627. The climate of these islands is generally moist and unhealthy. Their principal productions are, cocoa-nuts, rice, sago, cloves, ginger, mace, nutmegs, with several herbs and plants. No metals are found upon them, but pearls are said to be frequently met with on their coasts. Goats are the most common animals on these islands, and snakes of various descriptions. But the birds of paradise, which are supposed to come from New Guinea, are taken in great numbers on the Moluccas, by means of bird-lime, and form a considerable article of traffic. At the discovery of these islands, two distinct races of people were found upon them, the Malays, or Mahommedans, on the sea-coast, and the oriental negroes, or Papuas, in the interior. The former speak a dialect of the Malay tongue, mixed with many foreign words; but the ancient Molucca or Tirnata language appeared to Dr. Leyden to have been an original tongue. They have adopted many of the tenets, or rather observances, of the Brahminical system, but many of them, named Shereefs, boast of their descent from Mahommed, and are held in great respect, especially if they have performed the pilgrimage to Mecca. The Papuas have been rapidly decreasing, and have wholly disappeared in most of the smaller islands. But they still exist in many of the more eastern islands, and hold undisturbed possession of New Guinea. The houses on these islands are generally raised on pillars 8 or 10 feet high, on account of the moisture, and are entered by means of a ladder, which is afterwards drawn up. The colour of the natives is a deep mixture of black and yellow, and their dispositions wild and ferocious. They subsist chiefly on sago. The men wear little covering, except a hat of leaves, and a piece of cloth round their middle; and the women are dressed in a large wide garment like a sack, with a remarkably broad hat on their heads. Their arms are a kind of light tough wood, arrows of reed, pointed with hard wood, and bucklers of black hard wood, ornamented with designs in relievo, made with beautiful white shells. They excel in the construction and management of their vessels, which resemble in great measure those which have been already described under the article Magindanao. See Sonnerat's *Voyage to the Spice Islands;* and Forrest's *Voyage to New Guinea.* (*q*)

MOLTON, South, a town of England, in Devonshire, is situated on an eminence on the western bank of the River Moult. The town consists of three streets, meeting at the market place, where the houses are large and neat. The public buildings are, the church, which is handsome and spacious, and the town-house. There is here a Free School, founded in 1614. Serges, shalloons, and felts, were manufactured here. The population of the parish, in 1811, was 555 families, and 2739 inhabitants. See the *Beauties of England and Wales*, vol. iv. p. 276.

MONAGHAN, an inland county in Ireland, in the province of Ulster, is bounded on the north by Armagh and Tyrone; on the east by the former county and Louth; on the south by Cavan and Louth, and on the west by Fermanagh. It is the smallest county in the province of Ulster, and indeed in all Ireland, with the exception of four counties in Leinster, viz. Louth, Dublin, Carlow, and Longford. The county of Armagh approaches nearest it in size, Monaghan, according to the best authorities, containing 179,600 Irish acres, and Armagh 181,450. It is divided into five baronies, Monaghan, Cremowine, Dartrey, Freugh, and Farney: the last is sometimes called Donaghmoyne. The number of parishes is 19. The principal towns are, Monaghan, Castle Blaney, Carrickmacross and Clones; but they are all poor and small places. Its length is about 30 miles, and its breadth 22. It is in the diocese of Clogher, and province of Armagh; and returns two members to Parliament. Monaghan is one of the most uninteresting and unimportant counties of Ireland, in almost every point of view—our notice of it, therefore, will be brief. Its surface is not mountainous, but in most parts is occupied by a number of hills, scattered in an irregular manner, without forming continued ridges or chains. On the borders of Tyrone and Armagh, however, these hills rise in height, and are more connected, partaking of the character of the adjacent Few mountains. In the interior of the county there are a number of bogs; but in some places these have been drained with great skill and labour, and at considerable expense; or, where they could not be drained, have been converted into sheets of water, which greatly add to the appearance of the county. The soil in general is cold and poor, but in some parts naturally rich. This character particularly applies to what is called the Mountain of Criene, an elevated tract of land, intersecting the centre of the county, the soil of which is a rich loam on limestone gravel. This tract is also rendered more fertile as well as picturesque by a number of small streams which flow through it. With the exception of a few spots, there is little or no wood; and this bareness is not compensated by field-enclosures, as the corn-fields are in general naked, and without hedge-rows.

There are no lakes of any size or beauty; and the only river of the least consequence is the Fener, which rises in the west of the county, and falls into Loch Earne. There are said to be some appearances of lead, iron, and other minerals; but if there are, they are neglected. Limestone, marl, and freestone, however, abound; there are some large quarries of the last in the hills on the borders of Tyrone; and on Cairnmore, the highest of these, excellent millstones are procured. The climate of Monaghan is cold and ungenial.

The agriculture of this county is in a very poor and depressed state. The largest property amounts to 33,000 acres; but in general the estates are small. Many of them are held under the Crown, since the Scotch colony was introduced here; and many small portions of land, some of which do not yield above 20*l.* annual income, are possessed by the descendants of Cromwell's soldiers. Nearly the whole of the land in the county is divided into very small tenures, called in Ireland *holdings.* The number of forty-shilling freeholders, according to the last returns to Parliament, was 5521; of 20*l.* 146; and of 50*l.* and upwards, 172. Few of the farms on the larger estates are let in perpetuity; the more general term is 21 years and a life, or three lives.

According to Sir Charles Coote, in his Survey of this county, the leased farms are under an average of ten acres; taking the large farms, they would not average 25; and as the small ones, which are far more numerous, do not average six, ten may be the mean rate of the whole county. From this account of the size of the farms, it will naturally be concluded that they are entirely arable, and that the agriculture practised on them cannot be good. A great part of the ground is dug with the spade, or, where a plough is used, it is the joint contribution of three or four farmers, one bringing the implement itself, another a horse or bullock, or even a milch cow, and a third attending himself. Many *holdings* are too small to maintain a family. Some only possess a *dry cot*, that is, a house without land; these purchase every year an acre or two of grass for their cow and horse, and *corn acres*, or ground for potatoes and oats. Yet even these poor creatures pay a high rent, from a guinea and a half to two guineas an acre. Flax, potatoes, and oats, are almost the whole produce of the soil: according to the statistical survey, the whole county has seldom 100 acres of wheat. Some bear, or bigg, (a coarse species of barley) is grown, and in a few rich spots barley is cultivated. The farmers, however, do not depend on these crops, but entirely on their flax, potatoes and oats. The pasture husbandry of this county is on a very limited scale, and not well managed: most of the small farmers keep one or two cows, and make butter; the principal markets for it are Monaghan and Newry. One cow is generally kept on every five acres; and one hundred weight of butter, per cow, is considered the usual produce. The stock consists of the small stunted breed, still so common in Ireland. Scarcely any sheep are kept: goats are numerous, and are found round the greater part of the cabins, many of the poorer families being supplied with the milk they use by this animal. Many hogs are kept; Carrickmacross is a great market for them.

The only manufacture in Monaghan is that of linen; and for it this county is rather celebrated. The inhabitants are chiefly weavers, as well as farmers; women hire themselves out to spin the yarn: their wages are 3*l.* 10s. or 4*l.* per annum, besides their board and lodging; if they spin at their own houses, they earn about three shillings a week. It requires about three weeks to weave a web of 25 yards; the average pay is 1*l.*; hence it appears that the weekly wages of a weaver is about 6s. 8d. The consumption of a manufacturing family, consisting of six individuals, is estimated at 5s. a week; their food being potatoes, herrings, and buttermilk: the weekly expense of an agricultural family, of the same number, is 7s. 6d. as they will occasionally use oat-meal, milk, and pork. The principal markets for the linens within the county are, Monaghan, Castle Blaney, and Carrickmacross. The linen trade of this county is averaged at about 200,000*l.* a year.

The catholics in this county are as five to one compared with the protestants; the latter are chiefly presbyterians. In the year 1792, there were 21,523 houses, and 118,000 inhabitants, in this county; on the supposition that there are 280 square miles, there will be 76.86 inhabitants to a square mile; and on the supposition that there are 179,600 acres, there will be 83 acres to each house. The state of the peasantry, from what has already been mentioned, it may be conceived, is wretched; and yet there are parts of the county where improvements are going on, and civilization is advancing. As a proof of the poverty of Monaghan, it may be stated, that, though the smallest county in Ulster, it contains more houses with only one hearth than any of the other counties, except Antrim, Armagh, Tyrone and Down; whereas Londonderry, which contains twice the number of acres, has only one half the number of one-hearth houses.

Monaghan has scarcely any antiquities, except a round tower, and two of those *raths* called Danish forts, at Clones. This place was formerly the seat of an episcopal see, and a borough; in the ruins of the abbey burial ground are several magnificent tombs. See Sir Charles Coote's *Survey of Monaghan*; Wakefield's *Ireland*; Dr. Beaufort's *Memoir of a Map of Ireland*. (w. s.)

MONACHISM. The origin of Monachism cannot be traced higher than the middle of the third century of the Christian era, though Roman Catholic writers have erroneously and unsuccessfully endeavoured to prove, that the Ascetics, who were not uncommon long before this period, were monks. The monastic state originated in the last: the first monk whose name has reached us is St. Paul, usually styled the hermit; he retired into upper Egypt in 250, and after having attained the extraordinary age of 113 years, died in 341. Nearly about the same period, Anthony, a young man of very moderate attainments in literature, but evidently possessed of a strong understanding, who was born in the lower parts of the Thebais, and possessed a small tract of very fertile land in that part of Egypt, sold his property, distributed it among his relations—and, leaving his home, retired at first among the ruins of the tombs—afterwards to a lonely, but shady and well watered spot in the desert, and ultimately fixed his residence on a hill near the Red Sea. He also lived to the very advanced age of 105, and before his death, a numerous body of men lived in community with him, and led, under his guidance and example, a life of *piety* and manual labour. Perhaps, therefore, he may more properly than Paul be regarded as the first monk, since he undoubtedly first established a monastery.

The first written rule for the conduct of the monks was composed by Pachomius, who lived in the reign of Constantine: Pachomius, with 1400 of his brethren, occupied the isle of Tabenne, in the Nile, and founded, besides, nine monasteries of men, and one of women: according to other accounts, the Isle of Tabenne contained about 13 monasteries; 30 or 40 monks occupied one house: 30 or 40 having composed a monastery; a Dean was placed over every 10 monks; a superior over every house; every monastery had its abbot; and a general director superintended all. All the monks met every Sunday at the general oratory of the monastery; and Easter was occasionally celebrated by the monks of all the communities, amounting to nearly 50,000, assembling in one body. The same mistaken views of religion which introduced and established monachism, induced some of the monks to aim at a still more retired mode of life, and what was deemed a higher degree of perfection. Hence, the monks were divided into two classes, the Cænobites, who lived in community, and the Anchorites, who lived in separate cells. Between these extremes, there seems to have been a third kind of establishment of monks; each separate cell of the Anchorites was surrounded by an enclosure, and their general precinct was called a Laura.

Besides these sects of monks, who renounced the world, and lived in perpetual celibacy, there was another order, which, however, was never numerous, who lived in a married state, and enjoyed their own property and possessions. Originally all monks were laymen: The council of Chalcedon expressly distinguishes them from the clergy, and ranks them with laymen; and it was not till the time of Clement V., A. D. 1311, that monks were obliged to take holy orders, that they might say private mass for the honour of God.

Anthony had enjoyed the friendship of Athanasius; and the latter introduced into Rome the knowledge and practice of the monastic life, about the year A. D. 341. At first, the uncouth and savage appearance of the Egyptian monks, whom Athanasius brought for the purpose of initiating the Romans, excited disgust and laughter: but these feelings soon gave way to an enthusiastic admiration of the new sect, and senators and matrons transformed their palaces and country seats into religious houses. About the same time monachism was introduced into Palestine, by Hilarian, and into Pontus, by Basil. In the year A. D. 370, Martin, "a soldier, an hermit, a bishop, and a saint," erected the first monastery in Gaul; his funeral is said to have been attended by 2000 of his disciples.

In the 6th century, a new order of monks arose, which reached a greater degree of influence and celebrity than any which had preceded it. St. Benedict, an Italian monk, was its founder; his religious rules were at first intended and framed merely for the government of a convent at Mount Cassino, between Rome and Naples, over which he presided, but it afterwards was adopted by, or forced upon, a very great number of monasteries. His rule was founded on that of Pachomius, though in many respects it deviated from it. His great object seems to have been, to render the discipline of the monks milder, their establishment more solid, and their manners more regular than those of other monastic establishments. The whole time of the monks of his order he directed to be divided between prayer, reading, the education of youth, and other pious and learned labours. All who entered his order were obliged to promise when they were received as noviciates, and to repeat their promise when they were admitted as full members of the society, that they would in no respect, and on no account, attempt to change or add to the rules which he had instituted. His rule was embraced by all the monks of the west. Benedict admitted both the learned and unlearned into his order; it was the duty of the first to assist at the choir; of the latter to attend to the household economy, and temporal concerns of the monastery. At this period, it may be observed, that the recitation of the divine office at the choir, (as it is called by the Catholics,) was confined to the monks; afterwards it was established as the duty of all priests, deacons, and sub-deacons. The Benedictines at first admitted none into their order, who were not well instructed how to perform it; but it was not necessary that they should be priests, or even in holy orders. Afterwards, many were admitted into the Benedictine order, who were ignorant of the duty of the choir; those were employed in menial duties: Hence the introduction of *Lay Brothers* into the Benedictine order. When first introduced, they were not considered as a portion of the monastic establishment, but as merely attached and subordinate to it; but, in course of time, both the order and the church acknowledged them to be, in the strictest sense of the word, professed religious. All other religious orders, both men and women, following the example of the Benedictines, have admitted lay brothers and sisters. In 1322, the council of Vienne ordered all monks to enter into the order of priesthood. The monks of Vallombrosa, in Tuscany, are the first among whom lay brothers are found under that appellation.

The irruption of the Lombards into Italy, and of the Saracens into Spain, and the civil wars in France after the death of Charlemagne, having introduced great disorder among the Benedictines, they were reformed by St. Odo, in his monastery at Cluni; and several monasteries adopted this reform. In the eleventh century, the Benedictine order again fell from its original purity and strictness. This gave rise to many attempts to restore it to its pristine form and object: Hence arose the Carthusians, the Camadules, the Celestines, the monks of Grandmont, the Congregation of St. Maur, and the celebrated monks of La Trappe.

In the eighth century, a kind of middle order between the monks and the clergy was formed; they were called the canons regular of St. Augustine; their dwellings and table were in common, and they assembled at fixed hours for the divine service; in these respects they resembled the monks; but they differed from them in taking no vows; and they often officiated in churches committed to their care. Having degenerated in the twelfth century, Pope Nicholas II. introduced a considerable reformation among them. At this period, they seem to have divided into several branches of the original order; some formed themselves into communities, in which there was a common dwelling and table, but each monk, after contributing to the general stock, employed the fruits of his benefices as he deemed proper. At the head of another sect was the Bishop of Chartres; he adopted a more rigid and austere mode of life. This sect renounced their worldly possessions, all private property, and lived exactly as the strictest order of monks did. This gave rise to the distinction between the *secular and regular canons*. The former observed the decree of Pope Nicholas II. the latter followed the Bishop of Chartres; they were called the regular canons of St. Augustine, because they were formed on the rules laid down by St. Augustine in his Epistles. They kept public schools for the instruction of youth, and exercised a variety of other employments useful to the Church. A reform was effected in the Augustines by St. Norbert; and as he presided over a convent at Primontre in Picardy, those monks who adopted his rule were called Primonstrabenses. They spread throughout Europe with great rapidity.

During this period convents of nuns were established, the institutes and regulations of which were similar to those adopted by the Benedictines and Augustines, or to the reformed branches springing from those two great orders.

Till the thirteenth century, these were the only orders of monks; at that period the mendicant orders arose: those were, the Franciscans, Dominicans, Carmelites, and the Hermits of St. Augustine. The establishments of the Mendicants seem to have been necessary, as the other monks had greatly degenerated; they were rich and indolent, and consequently totally unfit for the objects for which they were instructed. Innocent III. was the first Pope who perceived the necessity of instituting an order, who, "by the austerity of their manners, their contempt of riches, and the external gravity and sanctity of their conduct and manners," might rescue the church from the reproach which the monks had brought upon it.

The Franciscans were founded by St. Francis; he was the son of a merchant, but, as was usual in those times, he possessed little or no learning; the brethren of his order were called Friars, minors, or the little brethren. They chiefly were engaged in the more laborious parts of religion, in hospitals, in prisons, among the lower orders of the poor; in short, where danger, labour, or other causes kept away the Benedictines and Augustines, there they were to be found; where there was no hopes of remuneration, the Franciscan friars were sure to be found. Many of them were eminent for their learning, and some have been Popes.

Soon after the death of their founder, they were divided into three orders; the Conventual friars, who admitted some relaxation into their original rule; the Observantine friars, who observed the rule more strictly. In France, these were called Cordeliers, from the cord with which they fastened their habit; from the Observantines sprung the Recollects, or Grey-friars, and the Capuchins, so called from a patch worn by them on the back of their habits. The Conventual and the Observantine friars formed the first of the three orders, into which the followers of St. Francis were divided. The second order was remarkable for its extreme severity, and was called the order of the Poor Classes. The third order embraced persons of both sexes; they lived in the world, but were united by certain rules; this order was imitated by the Dominicans and Carmelites.

The Dominicans derived their name from St. Dominic; at first he adopted the rule of the Canons' regular of St. Augustine; afterwards he adopted that of St. Benedict; but the alterations and additions he introduced made it almost an entirely new rule. In a chapter of his order at Bologna in 1220, he obliged the brethren to take a vow of absolute poverty, and to abandon entirely all their revenues and possessions. The Dominicans were first called preaching friars, because public instruction was the chief object of their institution. In England they were called black friars. "During three centuries the Franciscans and Dominicans governed, with an almost absolute and universal sway, both state and church, filled the most eminent posts, both ecclesiastical and civil, taught in the universities and churches with an authority, before which all opposition was silent, and maintained the pretended majesty and prerogatives of the Roman pontiffs against kings, princes, bishops, and heretics, with incredible ardour and equal success. These two celebrated orders restored the church from that declining condition in which it had been languishing for many years, by the zeal and activity with which they set themselves to discover and extirpate heretics, to undertake various negotiations and embassies for the interests of the hierarchy, and to confirm the wavering multitude in their implicit obedience to the Roman Pontiffs." The Carmelite order was originally instituted in Palestine, whence in the thirteenth century it was brought into Europe. A reform was introduced with this order by St. Theresa; the reformed, from their not wearing shoes, were called the unshodden Carmelites. Pope Alexander IV. observing that the Hermits were divided into many classes, some following the maxims of Augustine, formed the design of uniting them into one religious order, and prescribed a rule for their government; hence originated the Mendicant order of the Hermits of Augustine. These, however, as well as the Carmelites, were very inferior in number, reputation and influence, to the Franciscans and Dominicans. The public attachment to all these mendicant orders was so strong and prevalent, that several cities were divided into four parts, for these four orders; the Dominicans had the first part, the Franciscans the second, the Carmelites the third, and the Hermits of Augustine the fourth; from no others except one of these orders would the people receive the sacrament, and the churches in which they preached were regularly and constantly filled. The appellation of Friars, given to all these orders, whereas that of monks was given to those which existed before them, points out the distinction between the meaning of these two appellations, which are often confounded; the monks never travelled through the country, and indeed never left their monasteries; the friars, on the contrary, spent their time for the most part in travelling.

We are informed by excellent authority, Mr. Charles Butler, that these "four orders are the only orders which the church has acknowledged to be Mendicant. An order is considered to be Mendicant, in the proper import of that word, when it has no fixed income, and derives its whole subsistence from casual and uncertain bounty, obtained by personal mendicity. To that St. Francis did not wish his brethren to have recourse, till they had endeavoured to earn a competent subsistence by labour, and found their earnings insufficient. But soon after the decease of St. Francis, the exertions, equally incessant and laborious, of his disciples, for the spiritual welfare of the faithful, appeared, in the universal opinion of the church, to be both incompatible with manual labour, and much more than a compensation to the public for all they could possibly obtain from it by mendicity. This opinion was unequivocally expressed by St. Thomas Aquinas, and sanctioned by a bull of Pope Nicholas III.; since that time the friars did not use manual labour as a means of subsistence, but resorted in the first instance to mendicity." Mendicity seems to have made no part of the original rules of the Dominicans, Carmelites, or Hermits of Augustine: and in consequence of the evils attendant on it, the Council of Trent confined mendicity to the Observantines and Capuchins, allowing the other Franciscan establishments, and almost all the establishments of the three other orders, to acquire permanent property.

In consequence of the progress of the Reformation, and the loss of influence and authority which the Franciscans and Dominicans had sustained, partly from this event, and partly from their own relaxation and misconduct, the Pope was extremely desirous of establishing a new order, which should fill their place, discharge their duty, and zealously oppose the Protestants. At this period, 1534, appeared Ignatius Loyola, a Spanish knight, originally an illiterate soldier, and then a fanatic of most wonderful zeal and talents. In this year he, with ten of his Capuchins, laid the foundation of the Society of Jesus, by the vow which they took in the chapel of Montmartre, near Paris. In 1540 and 1543, his Institute was approved by Pope Paul III. The Society of Jesus, or the Jesuits, as they are generally called, hold a middle rank between monks and the secular clerks, approaching nearer to the regular canons than to any other order; they lived separate from the multitude, and were bound by religious vows; but they were exempt from stated hours of worship, and other strict observances, by which the monks were bound. Their principal duty was to direct the education of of youth, and the consciences of the faithful, and to uphold the cause of the church by their missions, and their pious and learned labours. They were divided into three classes; the first of which were the professed members. These, besides, the ordinary vows of poverty, chastity, and obedience, bound themselves to go, without murmur, inquiry, deliberation, or delay, wherever the Pope should think fit to send them; they were Memdicants without property. The second class comprehended the scholars; these were possessed of large revenues; their duty was to teach in the colleges of the order. The third class comprehended the novices, who lived in the houses of probation. The secrets of the society were revealed only to a few even of the professed members. In the year 1776, Clement IV. suppressed the Jesuits; the society, however, was restored in 1814 by a papal bull.

As the Reformation begun by Luther was mainly occasioned by the gross abuse of monastic establishments; so in its earliest stages it brought about their fall in all countries which embraced the Protestant religion. Henry VIII. of England eagerly seized the opportunity of enriching himself and his favourites by the dissolution of abbeys, monasteries, convents, and all other Catholic establishments; the monasteries, of different ranks and classes, suppressed, amounted to 3182. Their annual revenue was estimated at the enormous sum (for those days) of 140,784*l.*; and the persons they contained are supposed to have amounted in number to about 50,000. Monasteries continued in the Catholic countries till the French Revolution swept them away in France, and the other countries in which the French gained an absolute sway, and greatly reduced their splendour and power in all the other countries into which the French army penetrated. At present they are partially restored; but their discipline and power are comparatively very low, and more in conformity to the failings of human nature, as well as to the spirit and real interests of religion. Having thus given a sketch of the origin and history of the rise of monachism, and of the different kinds of monks and friars, we shall now proceed to describe the laws and rules that relate to the monastic life, as they respect their dress, diet, manual labour, vows, superintendants, and different officers, &c.

I. On their admission the monks were obliged to change their dress. According to the original rule of Benedict, his disciples were at liberty to adopt the coarse and usual dress of the countries which they might chance to inhabit: and the ancient monks accordingly clad themselves in linen in Egypt, where it was a cheap and domestic manufacture; whereas the western monks used the habit common there, the pallium of the Greek philosophers, which many other Christians in those times did. The ancient tonsure, which was always practised on admission, consisted not in shaving the head, but in cutting the hair very short: their heads were wrapt in a cowl, in order that their attention might not be attracted and drawn aside by profane objects: their legs and feet were naked, except in very cold weather; and they generally made use of a long staff to assist their steps. The anchorites, however, were not so respectable in their appearance; they never bathed their limbs, or anointed them with oil; the bare ground, or at most a hard mat, was their bed; and the bundle of palm leaves on which they sat, during the day, served as their pillow at night. In course of time, the different orders of monks and friars were distinguished by their dress: the habit of the regular canons of Augustine was a long black cassock, with a white socket, and over that a black cloak and hood: they nourished their beards, and wore caps on their head: the habit of the regular canonesses was of the same colour as the habit of the canons. The habit of the Primonstrabensians was a white cassock, a socket over it, a long white cloak, and a cap of the same colour. The Benedictine monks wore a black loose coat or gown, made of stuff, reaching to the heels, a cowl of the same, and a scapulary—and under that another habit, as large as the former, made of white flannel, with boots on their legs. The Benedictine nuns had a black robe and scapulary, and under these a tunic of white or undyed wool; but during their attendance at the choir they wore a black cowl, similar to that of the monks. The Cistertian or Bernardine monks had the appellation of White Monks, from wear- a white cassock, with a narrow scapulary; when abroad they wore a black gown, but when attending the church, a white one: the nuns of the order wore habits of the same colour as those of the monks. The Dominicans, when abroad, wore a black cloak and hood over their white vestments, and in their convents they wore a white cloak and hood. The Francisans were called Greyfriars from the colour of their garment; their habit was a loose gown, reaching to the ancle, with a cowl and a cloak of the same; when they went abroad, they were barefooted, and girt themselves with cords. The dress of the Carmelite friars was a coat and scapulary of hair colour, with a white cloak and hood. The crossed or crutched friars anciently carried a cross fixed to a staff in their hand; but afterwards they substituted a cross of red cloth upon their back: their habit was of a blue colour. The Augustine friars wore a white garment and scapulary; but when in the choir or abroad, they wore a black cowl, with a large hood, and were girt with a black leather thong.

II. The rule of St. Benedict, founded on that of Pachomius, prescribed the original diet of the monks: according to it, they were allowed twelve ounces of bread, to be taken at two meals, one in the afternoon and one in the evening: the small loaves of six ounces each were called Paximaica. In some cases Pachomius allowed his monks a larger portion of bread, but they were obliged to work a longer period. The Egyptian monks were permitted to eat the small dried fish of the Nile: in process of time, different kinds of sea and river fish were allowed. Meat was expressly forbidden to be served to his disciples, except when illness absolutely required it: afterwards the flesh of birds, but not that of quadrupeds, was permitted: Cheese, fruit, sallad, were permitted; to abstain from boiled vegetables was deemed a merit. At the first institution of monachism, water was the only beverage. Benedict, because he could not persuade the monks to abstain altogether from wine, allowed them half a pint daily: this, in northern climates, where wine could not be easily and cheaply obtained, his disciples exchanged for beer or cider.

III. As at the institution of monachism, the monasteries had regular or permanent revenues, the monks were obliged to labour, in order to maintain themselves: but the produce of their labour went to the common stock; there was no private or exclusive property; such expressions as my book, my cloak, my shoes, according to Cassian, were not only forbidden, but severely punished. Their occupation consisted in cultivating the gardens and fields that belonged to the monasteries; in making their dress, utensils, and furniture; and sometimes, particularly latterly—as was particularly the case with the Benedictines, in cultivating science and classical literature. The Egyptian monks made wooden sandals, mats, and baskets, selling those which they did not need themselves. The monasteries, however, soon became rich, and then manual labour was neglected.

IV. The vows taken on becoming monks were those of poverty, obedience, and chastity; but originally these vows were not perpetually binding. Then the monastic life seems to have been a matter of free choice, not only at the monks' first entrance, but in their progress and continuance, and they might quit it without any punishment. The monks who married were not anciently obliged by law to dissolve their marriage: afterwards restraints were imposed in these respects. Whoever left his monastery was pursued and restored to it by the aid of the civil power. "The actions of a monk, his words, and even his thoughts, were determined by an inflexible rule, and a capricious superior: the slightest offences were corrected by disgrace or confinement, extraordinary fasts, or bloody flagellations; and disobedience, murmur, or delay, were ranked in the catalogue of the most heinous sins." The Egyptian monks, who seem to have been under the most rigid discipline, "were directed to remove an enormous rock; assiduously to water a barren staff that was planted in the ground, till, at the end of three years, it should vegetate and blossom like a tree; to walk into a fiery furnace; or to cast their infant into a deep pond." The spiritual exercises of the monks were perpetual repentance, extraordinary fasting, and extraordinary devotions. We have already mentioned, that originally the laws of monachism did not permit the monks either to wander about as mendicants, or to interest themselves in civil or ecclesiastical affairs; nor were they permitted to encroach on the duties or rights of the secular clergy, or to dwell in cities, but they were confined to the wilderness. "Whenever they were permitted to step beyond the precincts of the monastery, two jealous companions were the mutual guards and spies of each other's actions; and after their return they were condemned to forget, or at least to suppress, whatever they had seen or heard in the world. Strangers, who professed the orthodox faith, were hospitably entertained in a separate apartment; but their dangerous conversation was restricted to some chosen elders of approved discretion and fidelity. Except in their presence, the monastic slave might not receive the visits of his friends or kindred; and it was deemed highly meritorious, if he afflicted a tender sister or an aged parent by the obstinate refusal of a word or look."

V. Monasteries were commonly divided into several parts, and proper officers appointed over them: every ten monks were subject to one, who was called Decanus or Deacon: a centenarius presided over every 100. The principal monastic dignity was that of abbot: his power was very great; he was generally of a noble family, and his possessions as abbot were often very great. They were allowed to sit and vote in councils; originally their power was subordin te to that of the Bishop, and no one could build either an oratory or monastery without the consent of the Bishop of the district in which it was to be erected. The Dean used to keep an exact account of every man's daily task: this was brought to the steward of the house, who himself gave a monthly account to the abbot. The prior was often at the head of a great monastic foundation, but the abbey he ruled was generally subordinate to a greater abbey, from whence the officers and monks were brought; and the revenues were a part of the common stock. In some cases the subordinate abbey over which the prior presided paid an annual pension, as an acknowledgment of their subjection; in other respects, however, they acted as an independent body. The almoner had the oversight of the alms, which were duly distributed: The Pitancer distributed provisions on certain days above the common allowance. The chamberlain had the chief care of the dormitory. The cellarer was to procure provisions; the infirmarius took care of the sick; the sacrist of the holy vestments and utensils; the precentor or chanter directed the choir service.

The lands possessed by monasteries were held under the same tenure as all other land; and, till a comparatively late period, the abbots themselves led their quota of troops into the field. In the time of Charlemagne, fourteen monasteries of the empire furnished their proportion of soldiers. In 982 the bishop of Augsburg and the Abbot of Fulda were killed in the same battle. Charles Martel was opposed by troops collected and headed by an Abbot of Fontinelle.

Before concluding this article, we may add a few words respecting nuns. Their origin, institutions, rules, and presiding officers, were very similar to those of the monks. Originally there was a distinction between ecclesiastical and monastic virgins. The former were common in the church long before the latter. They were enrolled in the canon of the church; that is, in the catalogue of ecclesiastics. They lived privately in their father's houses, where they were maintained, or, in case of necessity, by the church. At first monastic virgins, or nuns, like monks, might mix again with the world, and even marry, without censure or punishment; but in the fourth and fifth centuries, the censures of the church began to be very severe against the marriage of perfect virgins. Before a woman was finally admitted to be a nun, it was necessary for her to pass her noviciate; after this, if she still persevered in her determination, she took the vows, and passed through the usual ceremonies; the principal of which were taking the veil, having their hair cut, and putting on a ring and a bracelet. The origin of the word nun is unknown; the right name is undoubtedly derived from the Greek *νοννς*, and the Latin *nonnæ*; but whence they are derived, or what is their original signification, has not been ascertained. Hospinian, in his treatise on monachism, says it is an Egyptian word, signifying a virgin; but Jerome applies it to widows preferring chastity, as well as virgins.

Bingham's *Antiquities of the English Church*, book ii.; Mosheim's *Ecclesiastical History*; *Symbolic Books*, by C. Butler; *Gibbon's Rome*, vol. vii.

MONARCHY. See GOVERNMENT.

MONASTERY. See MONACHISM.

MONEY.

THE word Money is defined by Mr. David Hume to be, "the instrument which men have agreed upon to facilitate the exchange of one commodity for another."

In our articles BANK, BULLION, CURRENCY, and EXCHANGE, the subject of money has been considered under several points of view, and in our articles NUMISMATOLOGY and POLITICAL ECONOMY, we shall have occasion to view the subject under other aspects.

In the present article we propose merely to give an account of the moneys used by the different civilized nations of the globe.

General Table of Moneys of Account, containing the Value of the Moneys of Account of different Places (expressed in Pence and Decimals of Pence, according to the Mint Price both of Gold and Silver in England; that is, £3 17s. 10½d. per Oz. for Gold, and 5s. 2d. per Oz. for Silver. From Kelly's *Universal Cambist*, vol. ii. p. 169.

Names of Places.	Names of Moneys.	Value in Silver. d. dec.	Value in Gold. d. dec.
Aix la Chapelle	Rixdollar current	31 40	31 43
Alicant	Libra or peso	39 40	37 38
Amsterdam	Rixdollar banco (agio at 4 *per cent.*)	54 64	variable*
	Florin banco	21 85	ditto
	Pound Flemish banco	131 10	ditto
	Rixdollar current	52 54	ditto
	Florin current	21	ditto
	Pound Flemish current	126	ditto
Antwerp	Pound Flemish (money of exchange)	123 25	123 87
	Florin (money of exchange)	20 54	20 64
	Pound Flemish current	105 65	106 18
	Florin current	17 60	17 70
Arragon	Libra jaquesa	49 25	46 75
Augsburg	Florin Giro, or money of exchange	32	31 83
	Florin current	25 20	25 07
Barcelona	Libra catalan	28 14	26 70
Basil	Rixdollar, or ecu of Exchange	47 27	47
	Rixdollar current	42 45	42 20
Bergamo	Scudo of 7 lire	35 67	36 50
Berlin	Pound banco	47 25	variable
	Rixdollar current	36	ditto
	Rixdollar in Fredericks	——†	39 68
Bern	Ecu of 3 livres	42 64	42 90
	Crown of 25 batzen	35 53	35 75
Bologna	Lira corrente	10 86	10 62
	Lira money of exchange	11 13	10 89
Bolsano	Florin giron, or money of exchange	33 26	33 08
	Florin moneta lunga, or currency	25 20	25 06
Bremen	Rixdollar current	37 80	variable
	Rixdollar in Carls d'or	——	39 68
Canary Isles	Real current	3 95	3 66
Cassel	Rixdollar current	37 80	variable
Cologne	Rixdollar specie of 80 Albuses	31 38	ditto
	Rixdollar current of 78 Albuses	30 60	ditto
Constantinople	Piastre, or dollar	13 12	uncertain
Dantzic	Gulden, or florin	9	9
Denmark	Rixdollar specie	54 72	——
	Rixdollar sundish specie	53 21	——
	Rixdollar crown money	48 37	——
	Rixdollar Danish currency	44 27	44 88
	Rixdollar Holstein currency	43 78	44 16
England	Pound sterling	240	240
Florence	Lira	8 10	8 53
	Ducat, or crown current	56 70	59 71
	Scudo d'oro, or gold crown	——	63 97
France	Livre Tournois	9 54	9 38
	Franc (new system)	9 70	9 52
Frankfort	Rixdollar convention money	37 80	37 65
	Rixdollar Muntze, or in small coins	31 50	——
Germany	Rixdollar current	37 80	variable
	Rixdollar specie	50 40	ditto
	Florin of the empire	25 20	ditto
	Rixdollar Muntze	31 50	ditto
	Florin Muntze	21	ditto
Geneva	Livre current	16 13	16 93
	Florin	4 60	4 84
Genoa	Lira fuori banco	7 99	7 83
	Pezza, or dollar of exchange	45 94	45 02
	Scudo di cambio, or crown of exchange	36 75	36 02
	Scudo d'oro marche	85 49	83 77
Hamburg	Mark banco (at a medium)	18 22	variable
	Pound Flemish banco	136 65	ditto
	Mark current	14 82	ditto
Hamburg	Pound Flemish current	111 15	ditto
Hanover	Rixdollar, *in cash*	42	42 26
	Rixdollar, *gold value*	39	39 24
Ireland	Pound Irish	221 56	221 56
Konigsberg	Gulden, or florin	12	variable
Leghorn	Pezza of 8 reals	46 75	49 16
	Lira moneta buona	8 13	8 55
	Lira moneta lunga	7 79	8 19
Leipsic	Rixdollar convention money	37 80	variable
	Rixdollar in Louis d'or or Fredericks	——	39 68
Lucca	Lira	7 40	7 77
	Scudo d'oro	55 50	58 27
	Scudo corrente	51 80	54 39
Malta	Scudo, or crown	21 32	23 34
Milan	Lira imperiale	10 41	10 53
	Lira corrente	7 36	7 44
	Scudo imperiale	60 90	61 60
	Scudo corrente	42 32	42 78
Modena	Lira	3 82	——
Munich	Gulden or florin	21	21 28
Nancy	Livre (money of Lorraine)	7 38	7 26
Naples	Ducat regno	40 80	uncertain
Navarre	Real	4 92	4 67
	Libra	8 21	7 79
Neufchatel	Livre Tournois	13 63	13 40
	Livre foible	5 45	5 36
Novi	Scudo d'oro marche	85 49	83 77
Parma	Lira	2 45	2 40
Persia	Toman of 100 Mamoodis	287 60	——
Poland	Gulden or florin	6 03	6 27
Portugal	Milree	68 75	67 34
	Old crusade	27 50	26 94
Prague	(*See Vienna.*)		
Riga	Rixdollar Alberts	52 54	variable
	Rixdollar currency (agio at 40 per cent.)	37 53	ditto
Rome	Scudo or crown	52 05	51 63
	Scudo di stampa d'oro	79 37	78 73
Russia	Ruble	38 50	39 35
St. Gall	Florin, money of exchange	27 44	variable
	Florin current	22 76	ditto
St. Remo	Lira	8 46	8 90
Sardinia	Lira	18 21	18 82
Sicily	Ounce	122 54	124 80
	Scudo or crown	49 02	49 92
Spain	Real of old plate	4 93	4 57
	Real of new plate	5 24	4 86
	Real of Mexican plate	6 55	6 07
	Real vellon	2 62	2 43
	Dollar of old plate or of exchange	39 45	36 59
Stralsund	Rixdollar of account	28 35	variable
	Pomeranian gulden	14 18	ditto
Strasburg	Livre and franc (*See France.*)		
	Florin	19 08	18 76
Sweden	Rixdollar	55 41	56 43
Switzerland	Franc (new system)	22 14	——
Trieste	Florin, Austrian currency	25 20	25 05
	Lira, Trieste currency	4 76	4 73
	Lira di piazza	4 65	4 63
Turin	Lira	11 28	11 23
Valencia	Libra	39 45	36 59
Venice	Lira piccola (in the old coins)	5 07	variable
	Lira piccola (in the coins introduced by the Austrians)	4 25	ditto
Vienna	Florin	25 20	25 05
Zante	Real	4 06	variable
Zurich	Florin, money of exchange	25 85	ditto
	Florin current	23 50	ditto

* In the places marked *variable*, the price of the coins is not fixed; and, therefore, the intrinsic value in gold of the moneys of account cannot be ascertained for any length of time.

† Where the columns are marked with a dash, it is to be understood that there is no coin in the metal of that column by which the moneys of account can be computed.

ALPHABETICAL TABLE

Of the State of the Real and Imaginary Moneys of the World.

† This mark is prefixed to the Imaginary Money, or Money of Account.

All Fractions in the *Value English* are parts of a Penny.

ABYSSINIA. See the article ABYSSINIA in vol. i. of this work.

ALEPPO, *Alexandretta*,

$3\frac{1}{3}$ Aspers	=	a Syaino.
24 Syainos	=	a Piastre.

ALTONA. See HAMBURG.

AMERICAN UNITED STATES.

		Value English. £	s.	d.
10 Mills	1 Cent	0	0	$0\frac{1}{2}$
10 Cents	1 Dime	0	0	$5\frac{7}{10}$
10 Dimes	1 Dollar	0	4	$3\frac{3}{4}$
10 Dollars	1 Eagle	2	3	$8\frac{2}{10}$

Almost all the coins of Europe are current in the United States; but the most common ones are Spanish dollars, and hence all other moneys have been referred to them.

Accounts are still kept in pounds, shillings, and pence currency, which varies greatly in the different States. The dollar in the currency of New York and Carolina is valued at 8s.; in New England and Virginia, 6s.; in South Carolina and Georgia, 4s. 8d.

ARABIA. *Medina, Mecca, Mocha, &c.*

A Carret		0	0	$0\frac{1}{8}$
$5\frac{1}{2}$ Carrets	a Caveer	0	0	$0\frac{125}{200}$
7 Carrets	a Comashee	0	0	$0\frac{2}{10}$
80 Carrets	a Larin	0	0	$10\frac{1}{8}$
18 Comashees	an Abyss	0	1	$4\frac{1}{5}$
60 Comashees	†a Piastre	0	4	6
80 Caveers	a Dollar	0	4	6
100 Comashees	a Sequin	0	7	6
80 Larins	†a Tomond	3	7	6

See the article ARABIA.

At Bassora accounts are kept thus—

10 Floose or Flouches	a Danim	0	0	$0\frac{5}{11}$
10 Danims	a Mamoodi	0	0	$5\frac{1}{2}$
100 Mamoodis	a Toman	2	5	10

The imaginary Toman and Mamoodi are only three-fourths of the value of the real ones.

At *Mocha* accounts are kept in Piastres of 80 Caveers current. Payments are made in Spanish Dollars, 100 of which pass for $121\frac{1}{2}$ Piastres; so that the Piastre is worth 3s. $8\frac{1}{2}$d. sterling.

AUSTRIA. *Vienna, Augsburg, &c.*

		Value English. £	s.	d.
A Fening		0	0	$0\frac{7}{60}$
2 Fenings	a Dreyer	0	0	$0\frac{7}{30}$
4 Fenings	a Cruitzer	0	0	$0\frac{7}{15}$
14 Fenings	a Grosh	0	0	$0\frac{19}{30}$
4 Cruitzers	a Batzen	0	0	$1\frac{13}{15}$
20 Cruitzers	a Kopfstuck	0	0	$8\frac{1}{4}$
15 Batzen	a Gould or Florin	0	2	4
90 Cruitzers	†a Rixdollar	0	3	6
30 Batzen	a Specie Dollar	0	4	8
60 Batzen	a Ducat	0	9	4

In a recent work, (*A Manual of Foreign Exchanges*, &c.) the Ducat is valued at 8s. 4d. and the rest in proportion.

BARBARY. *Algiers, Tunis, Tripoli, &c.*

An Asper		0	0	$0\frac{5}{9}$
3 Aspers	a Medin	0	0	$1\frac{2}{3}$
10 Aspers	a Rial old Plate	0	0	$6\frac{3}{4}$
2 Rials	a Double Real	0	1	$1\frac{1}{2}$
4 Doubles	a Dollar	0	4	6
24 Medins	a Silver Sequin	0	3	4
30 Medins	a Dollar	0	4	6
180 Aspers	a Zequin	0	8	10
15 Doubles	a Pistole	0	16	9

ALGIERS.

Accounts are now kept here in Saimes or Doubles of 50 Aspers, and in Patacas Chicas of 8 Temins or 232 Aspers.

3 Patacas Chicas	=	a Piastre.
$8\frac{1}{2}$ Patacas Chicas	=	a Sultanim.
2 Carûbes	=	a Temin.

A Pataca Chica is worth $11\frac{1}{2}$d. Sterling.

At *Tripoli* accounts are now kept in Piastres of 13 Grimellini, or 52 Aspers. The Piastre is worth 5s. 3d. Sterling.

At *Tunis* in Piastres of 52 Aspers; 12 Burbes being = 1 Asper.

BAVARIA. *Munich, Ratisbon, &c.*

White Money.

2 Hellars	1 Fennige	0	0	$0\frac{7}{80}$
4 Fennige	1 Kreutzer	0	0	$0\frac{7}{20}$
2 Kreutzers	1 Albus	0	0	$0\frac{7}{10}$
$2\frac{1}{2}$ Kreutzers	1 Land Muntze	0	0	$0\frac{7}{8}$
3 Kreutzers	1 Kayser grosch	0	0	$1\frac{1}{20}$
4 Kreutzers	1 Batze	0	0	$1\frac{2}{5}$
60 Kreutzers	1 Rixflorin or Gulden	0	1	9
$1\frac{1}{2}$ Rixflorin	1 Rixdollar	0	2	$7\frac{1}{2}$
2 Rixflorins	1 Specie Dollar	0	3	6
$5\frac{1}{3}$ Rixflorins	1 Ducat	0	9	4
$7\frac{1}{3}$ Rixflorins	1 Maximil. d'Or	0	12	10
11 Rixflorins	1 Carolin d'Or	0	19	3

Black Money.

3 Regensburgers	1 Groschen
4 Groschen	1 Schilling
8 Schillings	1 Pfund fening
41 Schillings	1 Pfund

The florin, white money, is 7 schillings, or 28 groschen, black money.

BOHEMIA. *Prague, Breslau, Presburg, &c.*

		Value English. £	s.	d.
A Fening		0	0	$0\frac{7}{90}$
2 Fenings	a Dreyer	0	0	$0\frac{3}{30}$
3 Fenings	a Grosch	0	0	$0\frac{7}{20}$
4 Fenings	a Cruitzer	0	0	$0\frac{7}{15}$
2 Cruitzers	a White Grosch	0	0	$0\frac{14}{15}$
60 Cruitzers	a Gould or Florin	0	2	4
90 Cruitzers	†a Rixdollar	0	3	6
2 Goulds	a Specie Dollar	0	4	8
4 Goulds	a Ducat	0	9	4

In a recent work (*A Manual of Foreign Exchanges*) the Ducat is valued at 8s. 4d. and the rest in proportion, as in Austria.

BRABANT. See Flanders.

BRAZIL. See Portugal.

CANADA. *Florida, Cayenne, &c.*

† A Denier		
12 Deniers	†a Sol	
20 Sols	†a Livre	
2 Livres		
3 Livres		
Livres		The value of the Currency alters according to the quantity of Gold and Silver Coins imported.
5 Livres		
6 Livres		
7 Livres		
8 Livres		
9 Livres		
10 Livres		

CAPE OF GOOD HOPE. See Holland.

CHINA. *Pekin, Canton, &c.*

		£	s.	d.
A Caxa or Cosh		0	0	$0\frac{2}{25}$
10 Caxa	a Candareen	0	0	$0\frac{4}{5}$
10 Candareens	a Mace	0	0	8
35 Candareens	a Rupee	0	2	6
2 Rupees	a Dollar	0	4	6
70 Candareens	a Rixdollar	0	4	$4\frac{1}{2}$
7 Maces	an Ecu	0	5	0
2 Rupees	a Crown	0	5	0
10 Maces	†a Tale or Lyang	0	6	8

See the article China.

COLOGNE. *Mentz, Triers, Liege, Munster, Paderborn, &c.*

		£	s.	d.
A Dute		0	0	$0\frac{7}{80}$
3 Dutes	a Cruitzer	0	0	$0\frac{21}{80}$
2 Cruitzers	an Albus	0	0	$0\frac{21}{40}$
8 Dutes	a Stiver	0	0	$0\frac{7}{10}$
3 Stivers	a Blaffert or Plapart	0	0	$2\frac{1}{16}$
4 Blafferts	a Copstuck	0	0	$2\frac{2}{5}$
40 Stivers	a Guilder	0	2	4
2 Guilders	a Hard Dollar.	0	4	8
4 Guilders	a Ducat	0	9	4

DENMARK. *Copenhagen, Sound, Bergen, Drontheim, &c.*

		Value English. £	s.	d.
A Skilling		0	0	$0\frac{9}{16}$
4 Pfennings	a Witten	0	0	$0\frac{3}{16}$
3 Wittens or 2 Fyrkes	a Skilling	0	0	$8\frac{9}{16}$
16 Skillings	†a Marc	0	0	9
20 Skillings	a Rixmarc	0	0	$11\frac{1}{4}$
24 Skillings	a Rixort	0	1	$1\frac{1}{2}$
4 Marcs	a Crown	0	3	0
6 Marcs	a Rixdollar	0	4	6
12 Marcs	a Ducat	0	9	0

In *Holstein* and *Sleswig* accounts are kept in Rixdollars of 48 Skillings, or Marcs of 6 Shillings.

At *Elsineur*, in Rixdollars of 4 Orts, or 96 Skillings Danish.

At *Christiania, Drontheim, Larwigen*, &c. accounts are kept in Rixdollars of 4 Orts, or 96 Skillings Danish.

DUNKIRK. *St. Omers, St. Quintin, &c.*

		£	s.	d.
A Denier		0	0	$0\frac{1}{24}$
12 Deniers	a Sol	0	0	$0\frac{1}{2}$
15 Deniers	†a Patard	0	0	$0\frac{5}{8}$
15 Sols	†a Piette	0	0	$7\frac{1}{2}$
20 Sols	†a Livre Tournois	0	0	10
3 Livres	an Ecu of Ex.	0	2	6
24 Livres	a Louis d'Or	1	0	0
$25\frac{1}{2}$ Livres	a Guinea	1	1	0
$32\frac{2}{5}$ Livres	a Moeda	1	7	0

EAST INDIES.

Bengal, Calcutta, &c.

		£	s.	d.
A Pice		0	0	$0\frac{1}{32}$
4 Pices	a Fanam	0	0	$0\frac{5}{8}$
6 Pices	a Viz	0	0	$0\frac{15}{16}$
12 Pices	an Ana	0	0	$1\frac{7}{8}$
10 Anas	a Fiano	0	1	$6\frac{3}{4}$
16 Anas	a Rupee	0	2	6
2 Rupees	a French Ecu	0	5	0
2 Rupees	an English Crown	0	5	0
56 Anas	a Pagoda	0	8	9

Bombay, &c.

		£	s.	d.
4 Reas	an Urdee	0	0	$0\frac{1}{7}$
6 Reas	a Doreca	0	0	$0\frac{3}{7}$
4 Reas	a Dooganey	0	0	$0\frac{2}{7}$
8 Reas	a Fuddea or Double Pice	0	0	$0\frac{4}{7}$
25 Reas	an Ana	0	0	$1\frac{3}{4}$
16 Pices	a Laree	0	0	$4\frac{1}{3}$
20 Pices	a Quarter	0	0	$6\frac{3}{4}$
240 Reas	a Xeraphim	0	1	$4\frac{1}{5}$
4 Quarters	a Rupee	0	2	3
14 Quarters	a Pagoda	0	8	0
5 Rupees	a Paunchea	0	11	3
60 Quarters	a Gold Rupee or Mohur	1	15	0

Goa, Visapour, &c.

		£	s.	d.
†A Rea		0	0	$0\frac{27}{400}$
2 Reas	a Bazaraco	0	0	$0\frac{27}{200}$
2 Bazaracos	a Pecka	0	0	$0\frac{27}{100}$
20 Reas	a Vintin	0	0	$1\frac{7}{25}$
4 Vintins	a Laree	0	0	$5\frac{2}{5}$
3 Larees	a Xeraphim	0	1	$4\frac{1}{5}$
42 Vintins	a Tangu	0	4	6
4 Tangus	a Paru	0	18	0
8 Tangus	a Gold Rupee	1	15	0

EAST INDIES—*Continued.*

Guzerat, Surat, &c.

		£	s.	d.
A Pecka		0	0	$0\frac{15}{64}$
2 Peckas	a Pice	0	0	$0\frac{15}{32}$
4 Pices	a Fanam	0	0	$1\frac{7}{8}$
5 Pices	a Viz	0	0	$2\frac{11}{32}$
10 Pices	an Ana	0	0	$7\frac{1}{2}$
4 Anas	a Rupee	0	2	6
14 Anas	a Pagoda	0	8	9
4 Pagodas	a Gold Rupee	1	15	0

(Value English.)

Madras, &c.

		£	s.	d.
A Cash		0	0	$0\frac{1}{30}$
5 Cash	a Viz	0	0	$0\frac{1}{6}$
2 Viz	a Pice	0	0	$0\frac{3}{9}$
6 Pices	a Pical	0	0	$2\frac{1}{40}$
8 Pices	a Fanam	0	0	$2\frac{7}{10}$
10 Fanams	a Rupee	0	2	3
36 Fanams	a Pagoda	0	8	0
4 Pagodas	a Gold Rupee or Mohur	1	15	0

At *Anjengo*, they use Fanams, Pice, and Budgerooks. 4 Budgerooks = a Pice; 12 Pice or 16 Viz = a Fanam.

At *Calicut*, they use Gallee Fanams of 16 Viz or Tars; 5 Fanams being reckoned 1 Rupee.

At *Cambay*, accounts are kept in Rupees of 48 Pezas. A Rupee is worth about 2s. Sterling.

At *Ceylon, Java, Malacca, Molucca Islands, Palembang*, accounts are kept in Rixdollars of 48 Stivers Indian. A Rixdollar = 3s. 4d. Sterling.

At *Tranquebar*, in Rixdollars of 12 Fanams; and in Rupees of 8 Fanams.

At *Pondicherry*, in Pagodas of 24 Fanams. 1 Fanam = 60 Cash.

At *Seringapatam*, in Cantery Pagodas, and Fanams. 10 Fanams = 1 Pagoda.

At *Siam*, in Catties = 20 Tales; 1 Tale = 4 Mecals, or 16 Miams, or 32 Fouangs.

At *Batavia* accounts are kept in Piastres or Rixdollars, of 60 light Stivers each, or 48 real Dutch Stivers.

EGYPT. *Old and New Cairo, Alexandria, Sayde, &c.*

		£	s.	d.
An Asper		0	0	$0\frac{3}{5}$
3 Aspers	a Medino	0	0	$1\frac{4}{5}$
24 Medini	an Italian Ducat	0	3	4
80 Aspers	†a Piastre	0	4	0
30 Medini	a Dollar	0	4	6
96 Aspers	an Ecu	0	5	0
32 Medini	a Crown	0	5	0
60 Aspers	a Sultanin	0	10	0
70 Medini	a Parga Dollar	0	10	6

At *Alexandria*, accounts are commonly kept as follows—

2 Forli	an Asper
6 Apers	a Medino
8 Barbi	a Medino
10 Medini	a Ducatello
30 Medini	a Griscio or Abuquelp
107 Medini	a Zenzerli
120 Medini	a Zumabob
146 Medini	a Sequin or Fundeclee
25,000 Medini	a Purse

ENGLAND AND SCOTLAND.

		£	s.	d.
A Farthing		0	0	$0\frac{1}{4}$
2 Farthings	a Halfpenny	0	0	$0\frac{1}{2}$
2 Halfpence	a Penny	0	0	1
4 Pence	a Groat	0	0	4
6 Pence	a Half Shilling	0	0	6
12 Pence	a Shilling	0	1	0
5 Shillings	a Crown	0	5	0
20 Shillings	†a Pound Sterling	1	0	0
21 Shillings	a Guinea	1	1	0

(Value English.)

EMBDEN. *East Friesland.*

20 Wittens	=	a Schaaf
10 Schaafs	=	a Gulden
10 Wittens	=	a Stiver
54 Stivers	=	a Rixdollar

The rixdollar current is also subdivided into 3 marcs, 9 shillings, 18 flinderkes, 27 schaafs, 72 groots, 108 syferts, and 216 oertgens.

FLANDERS AND BRABANT.

Antwerp, Brussels, &c.

		£	s.	d.
†2 Mites	a Pening	0	0	$0\frac{9}{128}$
4 Penings	an Ort	0	0	$0\frac{4}{36}$
8 Penings	†a Grote	0	0	$0\frac{9}{26}$
2 Grotes	a Patard or Stiver	0	0	$0\frac{9}{16}$
$3\frac{1}{2}$ Stivers	a New Plaquette	0	0	3
6 Patards	†a Scalin	0	0	$5\frac{2}{5}$
7 Patards	a Scalin	0	0	$6\frac{3}{16}$
40 Grotes	†a Florin	0	1	6
48 Stivers	a Rixdollar	0	3	7
$61\frac{1}{5}$ Stivers	a Ducattoon	0	5	5
$127\frac{1}{6}$ Stivers	a Ducat	0	9	0
6 Florins	†a Pound Flem.	0	9	0

N. B. The Patards have for a long time been divided into 12 parts or Deniers.

FRANCE.

Paris, Lyons, Marseilles, &c. Bourdeaux, Bayonne, &c.

		£	s.	d.
A Denier		0	0	$0\frac{1}{24}$
3 Deniers	a Liard	0	0	$0\frac{1}{8}$
2 Liards	a Dardene	0	0	$0\frac{1}{4}$
12 Deniers	a Sol	0	0	$0\frac{1}{2}$
20 Sols	†a Livre Tournois	0	0	10
60 Sols	an Ecu of Ex.	0	2	6
6 Livres	an Ecu	0	5	0
10 Livres	†a Pistole	0	8	4
24 Livres	a Louis d'Or	1	0	0

In the new French system, accounts are kept in Francs, &c. thus:

		£	s.	d.
10 Decimes	1 Centime	0	0	$0\frac{1}{10}$
100 Centimes	1 Franc	0	0	10
80 Francs	81 Old Livres			
20 Francs	1 Louis	0	16	8

FRANCONIA. *Frankfort, Nuremberg, Dettingen, Darmstadt, Hanau, Mentz, &c.*

		£	s.	d.
A Fening		0	0	$0\frac{7}{60}$
4 Fenings	a Cruitzer	0	0	$0\frac{7}{15}$
2 Cruitzers	an Albus	0	0	$0\frac{3}{5}$

FRANCONIA. *Continued.*

		Value English. £	s.	d.
3 Cruitzers	a Kayser Grosh	0	0	$1\frac{2}{5}$
4 Cruitzers	a Batze	0	0	$1\frac{13}{15}$
15 Cruitzers	an Ort Gould	0	0	7
5 Batzen	a Kopfstuck	0	0	$9\frac{1}{3}$
60 Cruitzers	a Gould or Florin	0	2	4
90 Cruitzers	†a Rixdollar	0	3	6
2 Florins	a Specie Dollar	0	4	8
4 Florins	a Ducat	0	9	4

HAMBURG. *Altona, Lubec, Bremen, &c.*

		£	s.	d.
A Pfennige		0	0	$0\frac{1}{128}$
3 Pfennige	a Dreyling	0	0	$0\frac{3}{128}$
2 Dreyling	†a Zechsling	0	0	$0\frac{3}{64}$
2 Zechsling	a Pfennige	0	0	$0\frac{3}{32}$
12 Pfennige	a Schilling Lub.	0	0	$1\frac{1}{8}$
16 Schillings	†a Marc current	0	1	6
16 Schillings Banco	a Marc banco	0	1	6
2 Marcs	a Dollar of Exch.	0	3	0
3 Marcs	a Rixdollar	0	4	6
6 Marcs current	a Ducat current	0	8	0
13 Marcs current	a Pistole	0	16	9
12 Grotes	a Schilling Flem.	0	0	$6\frac{3}{4}$
20 Schillings	a Pound Flem.	0	11	3

N. B. The only gold coins at Hamburg are *ducats*, of the value of 7 marks 8 schillings, and *double ducats*, value 15 marks. The *Portugalese*, value 10 ducats, are more medals than coins, and are used as presents.

HANOVER. *Lunenburg, Zell, Wolfenbuttle, Brunswick, &c.*

		£	s.	d.
† A Pfennige		0	0	$0\frac{7}{48}$
3 Pfenniges	a Dreyer	0	0	$0\frac{7}{16}$
8 Pfenniges	a Marien Grosch	0	0	$1\frac{1}{6}$
12 Pfenniges	a Good Grosch	0	0	$1\frac{3}{4}$
8 Good Groschen	a Half Gulden	0	1	2
16 Groschen	a Gulden or Florin	0	2	4
24 Groschen	†a Rixdollar	0	3	6
32 Groschen	a Specie Dollar	0	4	8
4 Guldens	a Ducat	0	0	4

At *Bremen* accounts are now kept in Thalers or Rixdollars of 72 Grotes; and 5 Swares = a Grote.

HOLLAND. *Amsterdam, Rotterdam, Middleburg, Flushing, &c.*

		£	s.	d.
† A Pening		0	0	$0\frac{21}{320}$
2 Penings	a Druyt	0	0	$0\frac{28}{160}$
8 Peningens	†a Groot	0	0	$0\frac{21}{40}$
2 Groots	a Stiver	0	0	$1\frac{1}{20}$
2 Stivers	a Dubbeltie	0	0	$2\frac{1}{10}$
$2\frac{1}{2}$ Stivers	a Stooter	0	0	$2\frac{5}{8}$
$5\frac{1}{2}$ Stivers	a Sesthalf	0	0	$5\frac{1}{4}$
6 Stivers	a Scalin	0	0	$6\frac{3}{10}$
20 Stivers	a Guilder or Florin	0	1	9
8 Stivers	a Schilling Flem.	0	0	$8\frac{4}{10}$
50 Stivers	a Rixdollar	0	4	$4\frac{1}{2}$
60 Stivers	a Daalder	0	5	3
106 Stivers	a Ducat	0	9	4
6 Guilders or Florins	†a Pound Flem.	0	10	6
14 Florins	a Standpenning, or Ryder	1	4	10

N. B. The decimal system of monies is in force in the Netherlands by the present laws; but for the convenience of trade several judicious regulations have been adopted. The silver coins are the *florin*, which is of the same intrinsic value as the ancient Dutch florin. This florin is subdivided decimally into *cents*, thus—

1 Florin	100 Cents
Piece of $\frac{1}{2}$ a Florin	50 do.
Ditto of $\frac{1}{4}$ a Florin	25 do.
Ditto of $\frac{1}{10}$ a Florin	10 do.
Ditto of $\frac{1}{20}$ a Florin	5 do.

The copper coins are *cents*, or 100dth parts of a florin, and *half cents*, or 200dth parts of a florin.

The gold coins are pieces of 10 florins.

HOLSTEIN. See DENMARK.

HUNGARY. See the article HUNGARY.

IRELAND.

		Value English. £	s.	d.
A Farthing		0	0	$0\frac{3}{13}$
2 Farthings	a Halfpenny	0	0	$0\frac{6}{13}$
2 Halfpence	†a Penny	0	0	$0\frac{12}{13}$
$6\frac{1}{2}$ Pence	a Half Shilling	0	0	6
12 Pence	†a Shilling Irish	0	0	$11\frac{3}{40}$
13 Pence	a Shilling	0	1	0
65 Pence	a Crown	0	5	0
20 Shillings	†a Pound Irish	0	18	$5\frac{1}{2}$
$22\frac{3}{4}$ Shillings	a Guinea	1	1	0

ITALY. *Genoa.*

		£	s.	d.
12 Denari	a Soldo	0	0	$0\frac{1}{2}$
20 Soldi	a Lire	0	0	$8\frac{1}{3}$
26 Soldi	a Georgino	0	0	$10\frac{5}{6}$
115 Soldi	a Pezza of Exch.	0	4	0
8 Lire	a Silver Crown	0	5	6
24 Lire	a Gold Pistole	0	16	8
96 Lire	a Gold Genovine	3	2	8

Piedmont and Savoy.

		£	s.	d.
3 Denari	a Quattrino	0	0	$0\frac{1}{8}$
12 Denari	a Soldo	0	0	$0\frac{1}{2}$
12 Soldi	a Florin of Ex.	0	0	7
20 Soldi	a Lire	0	0	$11\frac{1}{2}$
6 Lire	a Scudo or Crown	0	5	9
24 Lire	a Doppia or Pistole	1	3	0
5 Pistoles	a Carlino	5	15	0

Milan, &c.

		£	s.	d.
3 Denari	a Quattrino	0	0	$0\frac{1}{11}$
12 Denari	a Soldo	0	0	$0\frac{3}{8}$
20 Centimes	a Soldo	0	0	$0\frac{3}{8}$
$2\frac{1}{2}$ Soldi	a Parpajole	0	0	$0\frac{7}{8}$
20 Soldi	a Livre	0	0	$7\frac{1}{2}$
115 Soldi	a Scudo current	0	3	$7\frac{1}{2}$
117 Soldi	a Scudo of Ex.	0	5	$2\frac{1}{2}$
106 Soldi of Ex.	a Phillip	0	4	$8\frac{1}{2}$
150 Soldi current	a Phillip	0	4	$8\frac{1}{2}$
8 Lire 12 Soldi	a Ducattoon	0	5	$4\frac{1}{2}$
15 Lire 4 Soldi	a Sequin	0	9	6
25 Lire 3 Soldi	a Pistole	0	15	9

Sardinia.

		£	s.	d.
2 Denari	a Cagliarese	0	0	$0\frac{1}{7}$
12 Denari	a Soldo	0	0	$0\frac{9}{10}$
20 Soldi	a Lire	0	1	6
5 Soldi	a Real	0	0	$4\frac{1}{2}$

ITALY—*Continued.*

		£	s.	d.
2½ Lire	a Scudo or Crown	0	3	$9\frac{1}{4}$
5 Lire	a Doppiete	0	7	6
25 Lire	a Carlino	1	19	2

Leghorn and Florence.

		£	s.	d.
4 Denari	a Quattrino	0	0	$0\frac{1}{7}$
12 Denari	a Soldo	0	0	$0\frac{2}{5}$
5 Quattrini	a Crazie	0	0	$0\frac{3}{4}$
8 Crazie	a Paolo	0	0	$5\frac{1}{2}$
3 Paoli or 2 Lire	a Testone	0	1	$4\frac{1}{4}$
60 Quattrini	a Lire	0	0	8
20 Soldi	a Lire	0	0	8
6 Lire	a Piastre of Ex.	0	4	0
7 Lire	a Scudo current	0	4	9
133¼ Soldi	a Francescone	0	4	6
23 Lire	a Doppia or Pistole	0	15	6

Rome.

		£	s.	d.
5 Quattrini	a Bajochi	0	0	$0\frac{1}{2}$
7½ Bajochi	a Carlino	0	0	$3\frac{1}{2}$
10 Bajochi	a Paolo	0	0	$5\frac{2}{5}$
50 Quattrini	a Paolo	0	0	$5\frac{2}{5}$
3 Paoli	a Testone	0	1	$4\frac{1}{5}$
10 Paoli or Giuli	a Scudo current	0	4	6
15¼ Paoli	a Scudo stamped	0	6	$7\frac{1}{4}$
16 Paoli	a Gold Ducat	0	7	$2\frac{1}{4}$
12 Denari	a Soldo	0	0	4
20 Soldi	a Scudo stamped	0	6	$7\frac{1}{4}$
21½ Paoli	a Sequin	0	9	3
31½ Paoli	a Doppia or Pistole	0	14	6

Naples.

		£	s.	d.
3 Quattrini	a Grain	0	0	$0\frac{2}{5}$
10 Grains	a Carlino	0	0	$4\frac{1}{5}$
20 Grains	a Taro	0	0	$8\frac{2}{5}$
5 Tari	a Ducat	0	3	6
45 Carlini	a Pistole Specie	0	15	9
125 Grains	a Specie Dollar	0	4	$4\frac{1}{2}$

Sicily and Malta.

		£	s.	d.
6 Pichili	a Grain	0	0	$0\frac{2}{11}$
8 Pichili	a Ponti	0	0	$0\frac{1}{4}$
10 Grains	a Carlino	0	0	$1\frac{2}{3}$
20 Grains	a Taro	0	0	$3\frac{1}{3}$
6 Tari	a Florin of Ex.	0	1	8
12 Tari	a Ducat of Ex.	0	3	4
60 Carlini	an Ounce	0	8	4
2 Ounces	a Pistole	0	16	8

Bologna, &c.

		£	s.	d.
6 Quattrini	a Bajocchi	0	0	$0\frac{3}{5}$
10 Bajocchi	a Julio	0	0	6
20 Bajocchi	a Lira	0	1	0
6 Julios	a Testone	0	1	6
85 Bajocchi	a Crown of Ex.	0	4	3
100 Bajocchi	a Crown	0	5	0
105 Bajocchi	a Ducattoon	0	5	3
31 Julios	a Pistole	0	15	6

JAPAN. *Jeddo, &c.*

		£	s.	d.
A Piti		0	0	$0\frac{1}{5}$
20 Pitis	a Mace or Mas	0	0	4
10 Maces	a Cindorine	0	3	4

JAPAN—*Continued.*

		£	s.	d.
15 Maces	an Ounce Silver	0	4	$10\frac{1}{3}$
20 Maces	a Tale or Tayel	0	6	8
30 Maces	an Ingot	0	9	$8\frac{2}{3}$
13 Ounces Silver	an Ounce Gold	3	3	0
2 Ounces Gold	a Japanese	6	6	0
2 Japanese	a Double	12	12	0
21 Ounces Gold	†a Cattee	66	3	0

The Dutch are said to reckon the Tale at 3½ Florins, which is nearly 6s. 2.d Sterling, which is considerably different from the value in the preceding Table.

LAPLAND. See Sweden.

LISLE. *Cambray, Valenciennes, &c.*

		£	s.	d.
A Denier		0	0	$0\frac{1}{24}$
12 Deniers	a Sol	0	0	$0\frac{1}{2}$
15 Deniers	a Patard	0	0	$0\frac{5}{8}$
15 Patards	†a Piette	0	0	$9\frac{3}{4}$
20 Sols	a Livre Tournois	0	0	10
20 Patards	†a Florin	0	1	$0\frac{1}{2}$
60 Sols	an Ecu of Ex.	0	2	6
10½ Livres	a Ducat	0	9	3
24 Livres	a Louis d'Or	1	0	0

LIVONIA. *Riga, Revel, Narva, Libau, &c.*

		£	s.	d.
A Blacken		0	0	$0\frac{1}{16}$
6 Blackens	a Grosh	0	0	$0\frac{3}{8}$
9 Blackens	a Vording or Ferding	0	0	$0\frac{9}{16}$
2 Groshen	a Whiten	0	0	$0\frac{3}{4}$
6 Groshen	a Marc	0	1	$2\frac{1}{8}$
30 Groshen	a Florin	0	3	$0\frac{3}{4}$
90 Groshen	†a Rixdollar	0	0	6
108 Groshen	an Alberts Dollar	0	4	6

At *Narva* accounts are now kept in Rubles of 10 Griven, or 100 Copecs.

At *Revel* accounts are now kept as at St. Petersburg, though sometimes in Rixdollars of 80 Copecs, or 62 Wittens.

MALTA. See Sicily.

MAJORCA, MINORCA.

Accounts are kept in pesos of 20 soldos, or 244 deneros; in Majorca often in pesos of 8 reals, or 27 maravedis of plate.

MEXICO.

Accounts are kept in Mexico in Pesos, or Dollars of 8 Reals, subdivided into 16 parts, and into 34 Maravedis de Plata Mexicanos. The Quarters are called Pecetas Mexicanos. A Doubloon of 8 Escudos of gold is worth 15 Pesos.

MOROCCO. *Santa Cruz, Mequinez, Fez, Tangiers, &c.*

		£	s.	d.
A Fluce		0	0	$0\frac{1}{12}$
24 Fluces	a Blanquil	0	0	2
4 Blanquils	an Ounce	0	0	8
7 Blanquils	an Octavo	0	1	2
14 Blanquils	a Quarto	0	2	4
2 Quartos	a Medio	0	4	8
28 Blanquils	a Dollar	0	4	6
54 Blanquils	a Xequin	0	9	0
100 Blanquils	a Pistole	0	16	9

MOROCCO—*Continued.*

The following state of the monies of Morocco is more modern:

		Value English. £	s.	d.
20 Fluces (copper)	1 Blanquillo (silver)	0	0	$2\frac{1}{6}$
10 Fluces (silver)	1 Ducado (gold)	0	8	8

The *Mitkal*, says Mr. Jackson, called by Europeans ducat, is worth eight-tenths of a Mexican dollar, or 3s. 8d. Sterling.

MUSCOVY. See Russia.

NORWAY. See Denmark.

NOVA SCOTIA. *Virginia, New England, &c.*

		£	s.	d.
†A Penny		0	0	1
12 Pence	†a Shilling	0	1	0
20 Shillings	†a Pound	1	0	0
2 Pounds				
3 Pounds				
4 Pounds				
5 Pounds				
6 Pounds				
7 Pounds				
8 Pounds				
9 Pounds				
10 Pounds				

The value of the currency alters according to the plenty or scarcity of Gold and Silver Coins that are imported.

PERSIA. *Ispahan, Ormus, Gombroon, &c.*

		£	s.	d.
4 Coz	a Bisti	0	0	$1\frac{2}{8}$
5 Bisti	a Shahee	0	0	$2\frac{1}{2}$
2 Shahees	a Mamouda	0	0	$4\frac{3}{4}$
$2\frac{1}{2}$ Mamoudies	a Larin	0	1	0
2 Mamoudies	an Abashee	0	0	$9\frac{1}{2}$
5 Mamoudies	a Rupee	0	2	6
10 Mamoudies	a Haeserdenaer	0	5	0
100 Mamoudies	a Tomond	2	10	0

POLAND. *Dantzic, Konigsberg, &c.*

		£	s.	d.
6 Pfenings	a Schilling	0	0	$0\frac{1}{6}$
3 Schillings	a Grosche	0	0	$0\frac{1}{2}$
6 Groschen	a Kopfstuck	0	0	$3\frac{1}{4}$
18 Groschen	a Timpfe	0	0	10
30 Groschen	a Florin or Gulden	0	1	$4\frac{3}{4}$
90 Groschen	a Rixdollar	0	4	$2\frac{1}{4}$
5 Rixdollars	a Frederic d'Or	1	1	0

PORTUGAL. *Lisbon, Oporto, &c.*

		£	s.	d.
†A Rea		0	0	$0\frac{27}{400}$
10 Reas	a Half Vinten	0	0	$0\frac{27}{40}$
20 Reas	a Vinten	0	0	$1\frac{7}{20}$
5 Vintens	a Testoon	0	0	$6\frac{3}{4}$
4 Testoons	a Crusade of Exch.	0	2	3
24 Vintens	a New Crusade	0	2	$8\frac{2}{5}$
10 Testoons	†a Milrea	0	5	$7\frac{1}{2}$
48 Testoons	a Moidore	1	7	0
64 Testoons	a Joanese	1	16	0

PRUSSIA. *Berlin, Potsdam, Stettin, &c.*

		Value English. £	s.	d.
18 Deniers	a Grosche	0	0	$0\frac{1}{2}$
12 Pfenings	a Grosche	0	0	$0\frac{1}{2}$
24 Groschen	a Pound Banco }	0	3	$11\frac{1}{4}$
24 Groschen	a Dollar Banco }			
60 Groschen	a Florin	0	2	4
90 Groschen	a Rixdollar	0	3	0
100 Groschen	an Alberts Dollar	0	3	4
$2\frac{1}{4}$ Rixdollars	a Ducat	0	8	3
5 Rixdollars	a Frederic d'Or	0	16	7

RAGUSA IN DALMATIA.

Accounts are kept here in Ducats of 40 Grosetti of 6 Soldi each. In the public offices accounts are kept in Perperi of 12 Grosetti each. The Ducat is worth $13\frac{1}{4}$d. Sterling, which is nearly the value of the Turkish Piastre of the latest coinage.

RUSSIA. *Petersburgh, Revel, Archangel, &c. Moscow, &c.*

		£	s.	d.
A Poluscha				
2 Poluschas	a Denuscha	0	0	$0\frac{1}{5}$
2 Denuschas	†a Copec	0	0	$0\frac{21}{50}$
3 Copecs	an Altin	0	0	$1\frac{13}{50}$
10 Copecs	a Grievener	0	0	$4\frac{2}{5}$
25 Copecs	a Polpotin	0	0	$10\frac{1}{2}$
50 Copecs	a Poltin	0	1	9
100 Copecs	a Ruble	0	3	6
	an Imperial	1	12	10

SARDINIA. See Italy.

SAXONY. *Dresden, Leipsic, &c.*

		£	s.	d.
2 Hellers	a Pfening	0	0	$0\frac{1}{6}$
16 Hellers	a Mariengrosche	0	0	$1\frac{1}{4}$
12 Pfenings	a Grosche	0	0	$1\frac{1}{2}$
16 Groschen	a Gulden	0	2	0
24 Groschen	a Rixdollar	0	3	2
32 Groschen	a Specie Dollar	0	4	3
21 Groschen	a Meissner Gulden	0	2	$7\frac{1}{2}$
20 Groschen	an Old Schock	0	2	6
60 Groschen	a New Schock	0	7	6
4 Guldens	a Ducat	0	8	0
5 Rixdollars	an August d'Or	0	16	6

SAVOY AND SARDINIA. See Piedmont.

SCOTLAND. See England.

SIAM. *Sumatra, Java, Borneo, &c.*

		£	s.	d.
800 Cori	a Fettee	0	0	$0\frac{1}{17}$
$41\frac{2}{3}$ Fettees	a Cash	0	0	$2\frac{1}{2}$
3 Cash	a Satalee	0	0	$7\frac{1}{2}$
2 Satalees	a Sookha	0	1	3
4 Cash or Condorines	a Mace	0	0	10
6 Mace	a Patack	0	5	0
10 Mace	a Tale	0	8	4
2 Sookhas	a Tutal	0	2	6
12 Cash	a Rupee	0	2	6
24 Cash	a Rixdollar	0	4	6
39 Cash	a Ducattoon	0	7	3
30 Rixdollars	a Copang	6	15	0

SILESIA. See Bohemia.

SMYRNA.

Accounts are kept in Piastres or Dollars, which are divided into 12 Florins and 40 Paras or Medini. The English and Swedes make the Piastre=80 Asper; the Dutch, French, and Venetians=100, and the Turks, Greeks, and Persians=120.

SPAIN. *Madrid, Cadiz, &c.* Common Currency New Plate Money.

		Value English. £	s.	d.
2 Maravedies	an Ochavo .	0	0	$0\frac{27}{85}$
4 Maravedies	a Quarto .	0	0	$0\frac{11}{17}$
34 Maravedies	a Real Vellon .	0	0	$2\frac{7}{10}$
2 Reals Vellon	a Real new plate	0	0	$5\frac{2}{5}$
4 Reals Vellon	a Peceta new plate	0	0	$10\frac{4}{5}$
$2\frac{1}{2}$ Reals Vellon	a Mexican Real	0	0	$6\frac{3}{4}$
5 Reals Vellon	a Mex. Peceta	0	1	$1\frac{1}{2}$
16 Reals new plate	17 Reals old plate	0	7	$2\frac{2}{5}$
17 Reals old plate	32 Reals Vellon	0	7	$2\frac{2}{5}$
8 Reals old plate	a Dollar of Ex.	0	3	5
20 Reals Vellon	a Hard Dollar	0	4	6
375 Marav. old plate	a Ducat of Ex.	0	4	8
32 Reals old plate	a Pistole of Ex.	0	13	$6\frac{1}{2}$
80 Reals Vellon	a Dubloon or Pistole	0	16	9
40 Reals Vellon	an Escudo .	0	8	$4\frac{1}{2}$
4 Escudos or Crowns	a Double Pistole	1	3	6

Malaga, &c. Vellon Money.

5 Dineros .	a Blanca .	0	0	$0\frac{1}{24}$
4 Blancos .	an Ochavo .	0	0	$0\frac{1}{6}$
2 Ochavos .	a Quarto .	0	0	$0\frac{1}{3}$
$8\frac{1}{2}$ Quartos .	a Real . .	0	0	$2\frac{7}{8}$
35 Maravedies	a Real . .	0	0	$2\frac{7}{8}$
4 Maravedies	a Quarto .	0	0	$0\frac{1}{2}$
15 Reals .	a Piastre or Dollar of Ex. .	0	3	7
60 Reals 8 Mar.	a Pistole of Exchange .	0	14	4
70 Reals .	a Pistole Specie	0	16	9

Barcelona, &c. Old Plate Money.

2 Mallas .	a Dinero .	0	0	$0\frac{1}{4}$
12 Dineros .	a Sueldo .	0	0	$1\frac{1}{2}$
$3\frac{1}{2}$ Sueldos .	a Real old plate	0	0	$5\frac{1}{8}$
20 Sueldos .	a Libra .	0	2	6
$5\frac{5}{7}$ Reals old plate	a Libra .	0	2	6
28 Sueldos .	a Dollar of Exch.	0	3	6
36 Sueldos .	a Hard Dollar	0	4	6
38 Sueld. $7\frac{1}{2}$ Dinero	a Ducat of Exch.	0	4	10
5 Libras 12 Sueldos	a Dubloon of Ex.	0	14	0

Valencia and Alicant. Old Plate Money.

12 Dineros .	a Sueldo .	0	0	$2\frac{1}{1}$
24 Dineros .	a Real new plate	0	0	4^{1}
$2\frac{1}{2}$ Sueldos .	a Real old plate	0	0	5^{1}
20 Sueldos .	a Libra .	0	3	6
a Libra .	a Dollar of Exch.	0	3	6
26 Seuld. $6\frac{3}{4}$ Din.	a Hard Dollar	0	4	6
4 Libras .	a Pistole of Exch.	0	14	0
$126\frac{1}{4}$ Sueldos .	a Gold Pistole	1	2	$1\frac{1}{2}$

In *Arragon* accounts are kept in Libras Jacquesas of 28 Soldos, or 320 Dineros de Plata. The Libra is worth 4s. 3d.

In *Navarre* accounts are commonly kept in Reals of 36 Maravedies; but sometimes in Ducados, or Libras of 20 Soldos, or 240 Dineros.

STRALSUND.

Accounts are kept here in Rixdollars=48 Schilling, and each Schilling=1 Pfening; also in Pomeranian Guilders of 24 Schillings current.

SWABIA. See AUSTRIA.

SWEDEN AND LAPLAND.

		Value English £	s.	d.
3 Runstics .	a Slant .	0	0	$0\frac{9}{32}$
12 Runstics or Ores	a Skilling .	0	0	$1\frac{1}{8}$
8 Ores . .	a Copper Marck	0	0	$0\frac{3}{4}$
3 Copper Marcks	a Silver Marck	0	0	$2\frac{1}{4}$
4 Copper Marcks	a Copper Dollar	0	0	3
3 Copper Dollars	a Silver Dollar	0	0	9
48 Skillings .	a Rixdollar .	0	4	6
6 Silver Dollars	a Rixdollar .	0	4	6
2 Rixdollars	a Ducat .	0	9	0

SWITZERLAND.

Basil, Zurich, Zug, &c.

$1\frac{1}{3}$ Deniers .	a Pfening .	0	0	$0\frac{1}{10}$
12 Deniers .	a Sol . .	0	0	$1\frac{1}{2}$
2 Pfenings .	a Rap . .	0	0	$0\frac{1}{5}$
5 Pfenings .	a Creutzer .	0	0	$0\frac{1}{2}$
3 Creutzers .	a Grosche .	0	0	$1\frac{1}{2}$
$3\frac{3}{5}$ Creutzers .	a Swiss Batze	0	0	$1\frac{7}{8}$
4 Creutzers .	a Good Batze .	0	0	$2\frac{1}{4}$
6 Rappen .	a Plappert or Shilling . .	0	0	$1\frac{1}{5}$
20 Sols .	a Livre .	0	2	6
60 Creutzers .	a Gould or Florin	0	2	6
108 Creutzers .	a Rixdollar of Exch.	0	4	6

Bern, Lucern, Neufchatel, &c.

12 Deniers .	a Sol or Sou .	0	0	1
6 Deniers .	a Creutzer .	0	0	$0\frac{1}{2}$
9 Deniers .	an Escalin .	0	0	$0\frac{3}{4}$
4 Creutzers .	a Batze .	0	0	2
2 Sous . .	a Batze .	0	0	2
10 Batzen or 20 Sous	a Livre .	0	1	8
60 Creutzers .	a Gulden or Flor.	0	2	6
120 Creutzers .	a Rixd. or Ecu	0	5	0

Accounts are also kept here in Scores or Francs of 10 Batzes, or 40 Cruitzers, and in Crowns of 25 Batzes, or 100 Cruitzers.

Geneva, &c.

A Denier .	. . .	0	0	$0\frac{1}{32}$
2 Deniers .	a Denier current	0	0	$0\frac{1}{16}$
12 Deniers .	a Small Sol .	0	0	$0\frac{3}{8}$
12 Deniers current	a Sol current .	0	0	$0\frac{3}{4}$
12 Small Sols	†a Florin .	0	0	$4\frac{1}{2}$
20 Sols current	†a Livre current	0	1	3
$10\frac{1}{2}$ Florins .	a Patagon or Ecu	0	4	0
$15\frac{3}{4}$ Florins .	a Croisade .	0	5	$10\frac{7}{8}$
24 Florins .	a Ducat .	0	9	0

St. Gall, Appenzel, &c.

A Heller .	. . . .	0	0	$0\frac{1}{16}$
2 Hellers .	a Fening .	0	0	$0\frac{1}{8}$
4 Fenings .	a Cruitzer .	0	0	$0\frac{1}{2}$
12 Fenings .	†a Sol . .	0	0	$1\frac{1}{2}$
4 Cruitzers .	a Coarse Batze	0	0	2

SWEDEN AND LAPLAND.—*Continued.*

		Value English. £.	s.	d.
5 Cruitzers	a Good Batze	0	0	$2\frac{1}{2}$
20 Sols	†a Livre	0	2	6
60 Cruitzers	a Specie or Florin	0	2	6
	a Florin Current	0	2	0
102 Cruitzers	a Rixdollar	0	4	3

In 1798, when the Helvetic Republic was formed, an uniform system of money was introduced at the different Cantons, viz. in Franken, Batzen, and Rappen, thus, 10 Batzen = 1 Franc ; 10 Rappen = 1 Batze ; the Franc was equivalent to $1\frac{1}{2}$ Franc of France.

TRIESTE.

Accounts are kept here in Florins of 60 Creutzers, each of the latter being subdivided into 4 Pfenings ; and likewise in Lire of 20 Soldi, a Soldo being = 12 Denari.

TURKEY. *Morea, Candia, Cyprus, &c.*

		£.	s.	d.
A Mangar		0	0	$0\frac{3}{20}$
4 Mangars	†an Asper	0	0	$0\frac{3}{5}$
3 Aspers	a Para	0	0	$1\frac{4}{5}$
5 Aspers	a Bestic	0	0	3
10 Aspers	an Ostic	0	0	6
20 Aspers	a Solota	0	1	0
80 Aspers	†a Piastre or Grouch	0	4	0
100 Aspers	a Caragrouch	0	5	0
10 Solotas	a Xeriff	0	10	0

VENICE. *Bergham, &c.*

		£.	s.	d.
A Picoli		0	0	$0\frac{1}{36}$
12 Picoli	a Soldo	0	0	$0\frac{1}{3}$
$6\frac{1}{2}$ Soldi or Marchetti	†a Gross	0	0	$2\frac{1}{6}$
18 Soldi	a Jule	0	0	6
20 Soldi	a Lire	0	0	$6\frac{2}{3}$
3 Jules	a Testoon	0	1	6
124 Soldi	a Ducat current	0	3	$5\frac{1}{3}$
24 Grossi	†a Ducat of Ex.	0	4	4
17 Lires	a Sequin	0	9	2

WEST INDIES.

JAMAICA. *Barbadoes.*

		£.	s.	d.
† Halfpenny		0	0	$0\frac{57}{160}$
2 Halfpence	†a Penny	0	0	$0\frac{57}{80}$
$7\frac{1}{2}$ Pence	a Bit	0	0	$5\frac{3}{3}$
12 Pence	†a Shilling	0	0	$8\frac{11}{20}$
75 Pence	a Dollar	0	4	6
7 Shillings	a Crown	0	5	0
20 Shillings	†a Pound	0	14	3
24 Shillings	a Pistole	0	16	9
30 Shillings	a Guinea	1	1	0

The *Spanish* gold coins current here are, the doubloon, 5*l.* Jamaica currency, and 4*l.* 10*s.* Barbadoes currency, which is subdivided into the two pistole piece = $\frac{1}{2}$ a doubloon ; the pistole piece, and the half pistole.

The Portuguese gold coins are the Johanes or Joe = 5*l.* 10*s.* Jamaica currency, or 5*l.* Barbadoes currency, which is subdivided into the $\frac{1}{2}$ Joe, and the $\frac{1}{4}$ Joe. The Moidore is = 2*l.* Jamaica currency, and 1*l.* 17*s.* 6*d.* Barbadoes currency, and is subdivided into the $\frac{1}{2}$ Moidore.

The Jamaica currency is to pounds Sterling as 104*l.* to 100.

The silver coins of Jamaica and Barbadoes are dollars, with their subdivisions, the dollar being = 6s. 8d. Jamaica currency, and 6s. 3d. Barbadoes currency.

St. DOMINGO.

		Value English. £.	s.	d.
† A Half Sol		0	0	$0\frac{117}{640}$
2 Half Sols	†a Sol	0	0	$0\frac{117}{32}$
$7\frac{1}{2}$ Sols	a Half Scalin	0	0	$2\frac{11}{10}$
15 Sols	a Scalin	0	0	$5\frac{3}{8}$
20 Sols	†a Livre	0	0	$7\frac{5}{16}$
7 Livres	a Dollar	0	4	6
8 Livres	an Ecu	0	4	$10\frac{5}{2}$
26 Livres	a Pistole	0	16	9
32 Livres	a Louis d'Or	1	0	0

Accounts are now kept chiefly in dollars and cents ; and the monies are nearly the same as in the Leeward Islands ; 11 Scalins = 1 Dollar, and 1 Scalin = 9 cents, and 1 Doubloon = 16 Dollars.

LEEWARD ISLANDS. English.

Tortola, Antigua, St. Kitt's, Montserrat, and Dominica.

		Leeward Currency. £	s.	d.
2 Half Dogs	1 Dog	0	0	$1\frac{1}{2}$
$1\frac{1}{2}$ Dog	1 Stampe	0	0	$2\frac{1}{4}$
6 Dogs, or 4 Stampes	1 Bit	0	0	9
$1\frac{1}{2}$ Bit	1 Moco	0	1	$1\frac{1}{2}$
11 Bits	1 Cut Dollar	0	8	3
12 Bits, or 8 Mocos	1 Round Dollar	0	9	0
5 Round Dollars	1 Guinea	2	5	0
8 Cut Dollars	1 Joe	3	6	0
16 Round Dollars	1 Doubloon	7	4	0

WINDWARD ISLANDS. English.

Tobago, St. Vincent, and *Grenada* use nearly the same moneys as the Leeward Islands. *Stampes* are current principally in Tobago, and *Dogs* in St. Vincent and Grenada.

FRENCH ISLANDS.

Martinico, St. Lucia, Guadaloupe, Marigalante, &c. The currency is the same as in the Leeward Islands, the *Dog* being here called the *Noir ;* the *Stampe* the *Tempe ;* the *Bit* the *Escalin ;* and the *Dollar* the *Gourde.* The French settlers keep their accounts in Noirs, Sols, and Deniers. The Noir is = 2 Sols 6 Deniers, and the Doubloon = 144 Livres.

DUTCH ISLANDS.

St. Eustatia, St. Martin's, Curacoa.

		£	s.	d.
6 Stivers	1 Real or Schilling	0	0	$5\frac{1}{8}$
8 Reals	1 Piastre current	0	3	5
11 Piastres	1 Joe	1	17	7

SPANISH ISLANDS.

Cuba, Trinidad, and Porto Rico. The moneys in these islands are the same as those of Mexico. In Trinidad, since the English possessed it, the moneys of the Leeward Islands have been adopted.

ZEALAND. See DENMARK.

ZANTE.

Accounts are kept in Reali of 10 Lire or 100 Soldi or Aspri.

For farther information respecting the moneys of different nations, the reader is referred to the following works. Zanetti, *Nuova Racolta delle Monnete, et Zecche d'Italia*, 5 vol. J. M. Benaven, *Le Caisscr Italien*, 1787, 2 vols., also the Works of Kruse of Hamburg, Ricard of Amsterdam, Marien of Spain, Gerhart of Berlin, Dubost of London. See also an useful little work, entitled *A Manual of Foreign Exchanges*, Glasgow, 1820, from which we have taken some of the preceding tablets; but particularly that elaborate and excellent work, Dr. Kelly's *Universal Cambist*, in 2 vols. quarto. Lond. 1811, which contains the most copious information on the subject of Moneys, Coins, Weights, and Measures.

MONK, GEORGE. See ENGLAND.

MONKS. See MONACHISM.

MONMOUTHSHIRE, a maritime county in the south-west of England, is bounded on the north-east by Herefordshire, from which it is separated by the river Mynnow; on the east by Gloucestershire, from which it is divided by the Wye; on the south-east by the æstuary of the Severn, which divides it from Gloucestershire and Somersetshire; on the north-west by Brecknockshire; and on the west by Glamorganshire, from which it is divided by the Rumney. Its length is about 33 miles; its breadth about 24; its circumference about 110 miles; and its area about 516 square miles, or 330,000 acres. In point of size, therefore, it approaches nearest to Herefordshire; and of all the counties in England surpasses only Rutlandshire and Huntingdonshire. It is divided into six hundreds—Skenfreth, Usk, Abergavenny, Wentlog, Caldicot, and Raglan. Its principal towns are situated on the banks of the Wye and the Usk, and are, Monmouth, the county town, at the confluence of the Wye and the Mynnow; Chepstow, near the mouth of the Wye; Usk, on the river of the same name; Abergavenny, also on this river; Pontypool, on the Avon, a branch of the Usk; Caerleon, at the confluence of the Avon and Usk; and Newport, near the mouth of the Usk. Monmouthshire returns three members to Parliament, viz. two for the county, and one for Newport, Monmouth and Usk, conjointly; and is in the province of Canterbury, and diocese of Lambeth.

The natural divisions of this county are strongly marked by the river Usk; the eastward and larger portion partakes of the character of the adjoining county of Hereford, and is well wooded, low-lying, and fertile; the smaller western part partakes of the character of Wales, being mountainous, and in great part unfavourable to cultivation, though there are several long, narrow valleys in it, watered by rivulets which flow into the æstuary of the Severn. "This is properly the county of landscapes. In other districts of our island, extent excites admiration, but in Monmouthshire all are home views; even where the æstuary of the Severn forms a part of the enchanting scene, the points of the horizon are the hills of Gloucester and Somerset. The course of the Wye is every where interesting, in some places sublime; that of the Usk, fringed with woods, or bounded by rich meadows, is a scene of perpetual beauty. The whole county forms but one exquisite landscape, of which the British channel is the foreground. Hills covered with woods, which the roads beautifully limit, or boldly climb; valleys fertilized by streams; thickets endlessly diversified; turrets rising in coverts, and ruined arches almost buried within them; mutilated castles, and mouldering abbeys, partially concealed; hamlets, churches, cottages, houses, and farms, are blended into one general and extensive scene, while the mountains of Glamorgan and Brecon melt into a distant and magnificent horizon." Such is a general picture of this county; and as it is interesting and important, chiefly from its beauties, we shall almost exclusively confine this article to those particulars which form or illustrate them.

The vale of the Usk is the largest tract of level ground in the inland parts of the county; it extends to the west of the town of Usk, along the lands watered by the Ebwy; and to the south, between the Usk and the elevated ground, almost to New-bridge; it is a rich and fertile district, but exposed to the overflowing of the Usk and Ebwy. There is another vale, called the Vale of Usk, which stretches from beyond Abergavenny along both sides of the river to the foot of Clytha hills. But the most romantic, as well as the least known of the valleys of Monmouthshire, are those which are called the valleys of the Ebwy and Sorwy. Under this description is included the mountainous district watered by the Rumney, and the streams that fall into it and the Usk, called the wilds of Monmouthshire. One of these streams bursts through a deep, narrow, and woody glen, and is discovered only by its foam glistening through the thick foliage; this rivulet is crossed by a stone bridge, which leads to a narrow and rugged path that winds round the sides of the Beacon mountain; these are thickly clothed with underwood, and most beautifully adorned with hanging groves of oak, alder, beech, and "the wild rasps twining in the thickets, and the ground covered with the wood-strawberry." The Valley of Ebwyfach, or, as it is called by the natives, the Valley of the Church, is now entered; it is bounded on the east by a ridge called Milfichill, which divides it from the parishes of Llanfoist and Trefrechin; and on the west by the Beacon mountain, which divides it from the Valley of Ebwyfawr. The Beacon mountain, a narrow and lofty ridge, stretches between the two branches of the Ebwy, and terminates very near their junction; the scenery at their junction is uncommonly striking; on the one side, the great Ebwy rushes through the vale; on the other, the little Ebwy, foaming through a hollow and narrow glen, emerges from a thick wood. On a bridge over the great Ebwy, whence a path leads up the woody side of the mountain which bounds the valley, "I remained," says Mr. Cox, "for a considerable time, absorbed in the contemplation of the picturesque objects around me; objects which recalled to my recollection the milder cast of mountain scenery, which I formerly so much admired in the Alps of Switzerland." The features of the vale of Sorwy are more wild and romantic than those of the Ebwy; it is deeper and narrower. There are several other valleys in this county, but those just described are the most picturesque and most worthy of description.

The mountains harmonize with the valleys, and give effect to the scene. They are seldom indented or notched, and never shapeless. The most remarkable are, the Skyrryd, or St. Michael's Mount, the Sugar Loaf, and the Blorenge. The ridge of the Skyrryd is about a mile in length, seldom more than 40 or 50 feet broad, and in some places only 10 or 12. Its insulated situation, abrupt declivity, and cragged fissures, produce a very striking effect, though its elevation is not very considerable. The highest part, according to General Roy, is 1498 feet. It is divided into two unequal parts, by a separation which, viewed from the west, seems an enormous chasm. The superstition of the county dates this rent at the crucifixion of our Saviour. Hence the natives generally call it the Holy Mountain. The chasm is not less than 300 feet in breadth. The view from this mountain is very extensive; in some parts rich and beautiful, in other points picturesque, and even sublime. The Sugar Loaf is higher than the Skyrryd, regular and beautiful, and its outline smooth and soft. The highest point rises 1852 feet above the mouth of the Gavenny. The ascent is so extremely easy, that a light carriage may be driven within 100 paces of the summit, which is an undulating ridge, about $\frac{1}{4}$ mile in length, and 200 yards in breadth. The view from it commands the counties of Radnor, Shropshire, Brecon, Monmouth, Glamorgan, Hereford, Worcester, Gloucester, Somerset, and Wilts, and of course comprises all varieties of scenery. The Blorenge mountain forms part of the chain which extends from the confines of Brecon to Panteg, below Pontypool. It forms the north-east boundary of the valley, called Avon Lwyd. It enters into the composition of some beautiful landscapes, but cannot bear a comparison with the Skyrryd or Sugar Loaf.

Another peculiarity of this county consists in its woodlands, forests, and chaces, some of which are still of great extent, though most of them have been diminished by grants. The forest of Wentword seems to have been one of the most considerable, and even yet comprises nearly 2170 acres, thickly covered with timber-trees and underwood. Besides the two grand natural divisions of this county formed by the Usk, there is a rich and extensive plain on the shore of the Severn, called Caldicot Level, or the Vale of Troggy, and the level of Wentlog. The former extends from the village of Caldicot, nearly the whole way to Goldcliff, and consists of a large tract of land recovered from the sea. Some parts of the walls, which have been erected at a very great expense, are 12 or 14 feet high, falling back from the sea by a gradual slope. The masonry is flanked by a strong embankment of earth. Near the western extremity rises a promontory, almost surrounded by the sea, called Goldcliff. It rises abruptly to the height of about 60 feet. In an extent of 16 miles, this rock is the only natural barrier against the encroachments of the sea. It consists of limestone lying horizontally, intersected with siliceous crystallizations above a large bed of mica. The level of Wentlog, like that of Caldicot, is perfectly flat, and defended from the encroachments of the sea by embankments. It stretches from east to west between the rivers Usk and Rumney; and from north to south between the Bristol Channel and a ridge of hills. The ground in both these levels is cut into parallel ditches: in some the water stagnates; in others it runs in streams, which fall into the sea through flood-gates. From this view of the surface of Monmouthshire, it appears that nearly one-third of it is a rock-plain on the shores of the Severn and Bristol Channel; one-third consists of ground, the surface of which is beautifully variegated, the hillocks being cultivated or woody, and numerous streams running through it; and "one-third assumes the mildest character of mountains, abounding with lovely valleys." The soil of the whole county is of various kinds, but generally rich and fertile, lying on limestone. The climate is mild and temperate, except on the highest mountains, where it is sometimes very cold. It has been remarked, that the fogs seem to shift periodically; for some days they rest on the mountains, while the valleys are free from them; and then suddenly the valleys are exposed to them for some days, and the tops of the mountains are clear.

The rivers contribute much to the picturesque beauties of this county. The principal are the Wye, Usk, and the Rumney. The tributary and inferior streams are the Mynnow, the Trothy, the Ebwy, the Avon, the Pill, and Kebby. The Wye is justly deemed the most picturesque river in England. It enters Monmouthshire near its junction with the Mynnow. The banks of the Wye at this place are rich with wood and verdure. A little below it is joined by the Trothy. Below Redbrook it forms a grand sweep, flowing into an abyss between two ranges of lofty hills, thickly covered with wood. Still lower down lies the singularly situated village of Llandogo, scattered among trees upon the side of a hill. Here the river forms a smooth bay; and the effect of the whole scene is greatly heightened by a beautiful back ground, formed of some undulating hills. A little below this the river again takes a meandering course, and the fine ruins of Tintern Abbey break upon the view. After passing some cliffs, marshy land disfigures the banks of this river; but these continue but for a short way, when the noble ruins of Chepstow Castle, placed on the highest point of an immense perpendicular rock, arrests the eye. Still further down the stream, the high impending screen of rocks on each side gives great effect to the scenery. This river is navigable to Hereford. At Chepstow, the tide sometimes rises to the height of 50 feet. The Usk rises in the mountains of Brecon, and enters Monmouthshire at Llangwnny. It is a clear stream, richly skirted with wood; the mountains, which stretch from Abergavenny to Pontypool, forming a magnificent back ground. Some parts of its banks do not suffer even when compared with those of the Wye, with respect to picturesque beauty. It is navigable for barges up to Tredannoc Bridge. The Mynnow rises in a lake at the foot of Mynnyd Maen, runs by Pontypool, passes under the canal, and joins the river Usk in the valley beneath. There are some lakes in this county, but none of them remarkable either for size or picturesque beauty. The largest is that from which the Mynnow takes its rise. It is two miles in circumference, and stretches along the foot of the north-east extremity of Mynnyd Maen. It forms the reservoir of the Monmouthshire canal.

There are two canals in this county. The Monmouthshire canal was begun in the year 1792, and cost about 280,000*l.* including the railways connected with it. It commences on the west side of Newport, forming a basin connected with the Usk. Its line lies between that town and the river, and it afterwards crosses the road leading to Chepstow; thence by Malpas it runs parallel to the Avon, and near it, close to Pontypool, to Pontnewidd. This is one line of the Monmouthshire canal. Its whole length is 11 miles, with a rise of 12 feet in the first mile, and 435 feet in the other 10 miles. The other branch strikes off near Malpas, parallel to the Ebwy, to the vicinity of Crumlin Bridge, having a course of nearly 11 miles from the junction, with a rise of 358 feet. The total length, therefore, of the two lines, is 22 miles, with 808 feet lockage. There are several rail-roads from each of these branches to the iron works, coaleries, lime-works, &c. which abound in this part of Monmouthshire. One of the rail-roads, which is nine miles long, cost 40,000*l.* The highest point of elevation of the principal rail-way is 1230 feet, making the whole elevation 2035 feet above the entrance lock. The Brecon canal unites with the Monmouthshire canal about 8 miles from Newport, and 1 from Pontypool. It crosses the river Avon, where it is carried through the high lands by a tunnel 220 yards long. It afterwards passes the town of Abergavenny towards the Usk, parallel to which it leaves the county. A canal has recently been formed, which, at the distance of about a mile from Abergavenny, communicates with the Brecon canal, and promises to open a considerable trade with the former town.

The western division of Monmouthshire is rich in mineral treasures, particularly iron and coal. Near the source of the Avon is Blenavon, where immense works are established, which usually employ upwards of 400 men. The iron is conveyed to the canal on the rail-ways. Between Abergavenny and Usk are the Trostey iron-works. Iron bar is manufactured here, and conveyed down the Usk to Newport. Iron is found in several other parts, chiefly in the vicinity of Abergavenny. There are also extensive iron-works at Abercorn, consisting of a foundery, wire mill, rolling mill, &c. The Monmouthshire canal passes through these works. There are also large iron works near Pontypool. There are indications of lead, but not any mines of consequence. Coal abounds; and, since the Monmouthshire canal was completed, a number of coaleries have been opened, which before were unknown or neglected. There are several large ones about 17 miles from Newport; one of which raises nearly 100 tons a day. They are generally worked by levels. There is no stone coal. As proofs of the great activity and increase which bas been given to the coal trade, by the formation of the canal, it may be mentioned that the coals exported coastwise from Newport average about 150,000 tons, principally to Bristol, Bridgewater, and Gloucester. To Bristol alone, about 40,000 tons are exported; whereas, before the canal was made, none were sent. There are many quarries of breccia for mill-stones, and other valuable stone for building. Lime-stone of the best quality abounds, especially in the eastern division of the county, where it is burnt on the spot for the general manure of the county. The rivers are well stocked with fish. The salmon of the Wye and Usk are much celebrated for their flavour.

The agriculture of Monmouthshire presents nothing interesting. The eastern division contains a good deal of arable land; and in some of the vales near the Rumney, a large quantity of corn is grown. There is also very fine pasture land in the eastern division. The western division is chiefly devoted to the feeding of sheep. This county is not remarkable for its native breed of cattle or horses; but the finest mules in the kingdom are reared and worked in it and Brecon. They are from 14 to 16 hands high, and sell for 30 or 40*l.* In the neighbourhood of Monmouth, oxen are much used in agriculture. Many of the peasants keep bees. Orchards, on a small scale, are not uncommon.

The iron works of this county have been already mentioned. There are also several other manufactures, principally of metal. Near Caerleon there are very extensive tin-works, which are capable of manufacturing annually from 14,000 to 20,000 boxes of tin plates, containing each from 200 to 300 plates. Iron plates are here rolled, and iron shop-bolts and square bars made. The machinery of the mill is entirely iron. The iron plates made here are used in the manufacture of the Pontypool japanned ware. This was the invention of Thomas Allgood, in the reign of Charles II.; it is still carried on, but has much declined since the rise in the trade of Birmingham. There is also a manufactory of japan ware at Usk. Not far distant from Tintern Abbey is a manufactory for making wire, which begins with the thick iron bar, and proceeds to the smallest wire.

The roads in Monmouthshire, which were formerly very bad, have been much improved of late years; and, though still unavoidably hilly, are in other respects as good as in most other parts of England. The following are the results of the last accounts respecting them laid before Parliament:

	Miles.	*Furl.*
Length of paved streets and turnpikes in 1814, - - - - -	264	7
——— all other turnpikes, - -	772	2
	1037	0

Estimated value of labour employed on them, - - - -	£4033	0	0
Composition money - - - -	712	0	0
Highway rates, - - - - -	5635	0	0
Law expenses - - - - -	284	0	0
Total,	£10,664	0	0

At the time of the Roman invasion, this county was comprehended in the Silurian territory. It was afterwards called Givent. It was never completely conquered during the Saxon dynasty. William I. however, in a great measure subdued it, by directing his barons to make incursions at their own expense, and granting them the lands they conquered, to hold under feudal tenure. These barons, however, afterwards entrenched in strong castles, bid defiance to their Sovereign; feuds and animosities also arose between them. At length Henry VIII. abolished their petty governments, and added Monmouthshire to the English counties. It was still, however, considered in law as a Welch county till the time of Charles II. It abounds in antiquities, or rather in ruins, highly picturesque in themselves, and rendered still more so by the scenery of the surrounding country. The most celebrated of these are Tintern Abbey, and the Castle of Chepstow. Piercefield, near Chepstow, the once celebrated seat of Valentine Morris, may also be noticed, as uniting, with wonderful taste and effect, all the softer and richer beauties of this most interesting country. Raglan Castle is another place worth noticing, on account of its ruins, and the valiant defence it made in favour of Charles I. under the Marquis of Worcester.

The following are the results of the last returns to Parliament, respecting the poor-rates of this county, for the year 1815:

Annual value of real property, -	£295,097	
Poor and other parochial rates, - -	38,650	
Rate in the £ - - - - -		2 6¾
Expended in maintenance of the poor, -	27,049	
——— in lawsuits and removals,	1,878	
Militia expenses, - - - -	583	
Church rates, &c. - - - - -	11,209	
Total expenditure, - - - - -	£40,719	
Poor supported out of workhouses, - -	2314	
——— in workhouses, - -	87	
——— occasionally - - -	1587	
Total,	4788	
Members of Friendly Societies, - -	8404	
Donations for Parish Schools, - -	£166	
——— for other purposes - -	783	
Total,	£949	
Poor, and other parochial rates in 1776, -	£7468	
——— average of 1783, 4, 5, - -	9989	
——— of 1803, - - - - -	25,048	
——— average of 1813, 14, 15, -	37,846	
Total relieved in 1803, - - - - -	3430	
——— average of 1813, 14, 15, - -	4122	
Members of Friendly Societies, in 1803, -	3799	
——— average of 1813, 14, 15, -	7923	

Number of persons relieved, on an average of 1813, 14, and 15, 6½ in each 100. The average rate levied on each individual, 12s. 2¼d. The average sum for support of each poor person annually, 6*l.* 16s. 5½d. 1-19th of the money raised expended on law; and 1-34th for militia purposes—¼th for all other purposes—total expended, independent of maintenance of the poor, is ⅓d.—13 in each 100, members of friendly societies.

In the hilly district enclosed by the Usk and the Rumney, which once formed a little principality, and which is said to have been left undisturbed by the Romans, Saxons, and Normans, the customs and manners of ancient Britain are preserved more pure than in any other part of Wales. The following are the results of the last returns to Parliament, respecting the population of this county.

Population in the year	1700 - - -	39,700
	1750 - - - -	40,600
	1801 - - -	47,100
	1811 - - - -	62,127

One baptism to 47 persons; one burial to 64 persons; and one marriage to 153 persons; the last is a very small proportion, the average of England being one marriage to 120 persons. The total number of baptisms, from 1801 to 1810, both inclusive, was 11,834; of burials 8832; and of marriages, 4058. The small number of burials and marriages, compared to the population, and the low proportion of baptisms to marriages, are very striking; particular inquiry was made, in consequence, into the parish register returns, but without discovering the cause.

Houses inhabited in 1811, -	11,766	
Families occupying them, -	12,543	
Houses building, - -	158	
——— uninhabited, - -	361	
Families employed in agriculture,	5,815	
——— in trade, - -	4,812	
All others, - - -	1,916	
Males, - - - -	30,987	
Females, - - -	31,140	
Total in 1811,	62,127	or 126 to each square mile.
Population in 1801 - -	47,100	
Increase since 1801,	15,027	

See Coxe's *Picture of Monmouthshire*. Warner's *Walks in Wales*. Evans's *Tour in South Wales*. *Beauties of England and Wales*, vol. ii. (W. S.)

MONMOUTH, the county town of Monmouthshire, in the hundred of Skenfreth, lies in an angle between the Wye and the Mynnow. It is a borough and corporate town, governed by a mayor, two bailiffs, and common councilmen. It returns one member to Parliament, in conjunction with the inhabitants of Newport and Usk. This privilege was conferred on it by Henry VIII. It is accommodated with four bridges; one across the Wye, on the road to Gloucester; two over the Mynnow, and one over the Trothy. The streets, which are in the form of the letter H, are in some parts broad and convenient, but in other places narrow and irregular. The castle, once a place of great strength, and celebrated for having been the birth-place of Henry V., who bore the name of Henry of Monmouth, is now almost entirely in ruins. It stood on the rise of an eminence, on the banks of the Mynnow. The east end of the church is much admired as a fine specimen of Gothic architecture. The county gaol, on Howard's plan, combines strength, utility, and comfort. The walks in the vicinity are very pleasant; though these and the town itself are frequently enveloped in exhalations, occasioned probably from its low situation, and the vicinity of the rivers. Monmouth carries on a considerable trade with Bristol, by means of the Wye. It has three fairs, at which a large number of cattle, horses, sheep, and pigs, are sold; and also a large quantity of flannel. Its market is well supplied with all sorts of provisions. In 1801, it contained 667 houses, and 3345 inhabitants. In 1811, its population was as follows:

Houses inhabited, - - -	661
Families inhabiting them, - - -	753
Houses building, - - - -	4
——— uninhabited, - - - -	14
Families employed in agriculture, -	146
——— in trade, - -	375
All others, - - - - - -	232
Males, - - - - - -	1630
Females, - - - - -	1873
Total,	3503 (W. S.)

MONOCHORD, from *μονος*, *single*, and *χορδα*, *chord*, signifies properly any musical instrument which has only *one chord* or string, but is applied also to an instrument said to have been invented by Pythagoras for measuring geometrically the quantities and proportions of sounds. A paper by Dr. Wallis, on the division of the monochord, will be found in the *Philosophical Transactions* for 1698, vol. xx. p. 80.

MONONGAHELA, a river of the United States of North America, rises in Randolph county, Virginia, interlocking with the sources of the Great Kenhawa at N. Lat. 38° 30′. Its course is nearly south 80 miles, to where it receives the west branch, from Lewis and Harrison counties. Below their junction, the united stream flows south-east 30 miles to the south boundary of Pennsylvania, which it passes, and two miles lower receives from the south-east, Cheat river, little, if any, inferior in column or length to the Monongahela itself. Cheat river rises in Randolph county, and flows through that and Monongahela county, enters Pennsylvania, and unites with the main stream as before noticed. The sources of the Monongahela and Cheat are in the western spurs of the Appalachian mountains. Below the mouth of Cheat, the Monongahela flows nearly south 50 miles, to its junction with the Youghiogheny. The latter rises in the Appalachian mountains, in Allegheny county, in Maryland, interlocking with the sources of the North Branch of the Potomac, flows north into Pennsylvania, passing through Fayette, Westmoreland, and entering Allegheny county, unites with the Monongahela at M'Keesport, after a comparative course of about 100 miles. Twelve miles below its junction with Youghiogheny, the Monongahela unites with the Allegheny, and forms the Ohio at the city of Pittsburg. The entire length of the Monongahela river, by comparative courses, is about 170 miles, but following the meanders of the streams, either along the main or Cheat branch, the length exceeds 200 miles.

The country drained by the Monongahela is in some parts mountainous, and in all hilly.

For down stream navigation, the Monongahela, at high water, is passable with large boats as high as the mouth of the West Branch, and by lighter vessels much higher. Cheat river is navigable into Randolph county, about 50 miles comparative course above its mouth, and the Youghiogheny to the Ohiopyle falls, in Fayette county, 60 miles above its junction with the Monongahela. (Darby.)

MONRO, M. D. ALEXANDER, the son of Mr. John Monro, was born at London on the 19th September 1697, and descended, by his father, from the family of Monro of Milton, and by his mother from that of Forbes of Culloden. John Monro, the younger son of Sir Alexander Munro of Bearcroft, colonel in the army of King Charles at the battle of Worcester, and afterwards one of the principal clerks of the Court of Session, served for some years as a military surgeon under King William, in Flanders. Retiring from the army about the commencement of the last century, he established himself at Edinburgh, where his enlarged knowledge, unremitting attention, and agreeable manners, soon introduced him to an extensive practice. At the same time, professional engagements did not prevent him from attending to the education of an only son, whose early inclination to the study of medicine contributed to strengthen the desire he had long felt to supply the want of medical instruction in Edinburgh.

Mr. Monro, after receiving an excellent classical and mathematical education, and completing the usual course of academical studies, was bound an apprentice to his father, who procured him books necessary for his private studies, and a chemical apparatus for the purpose of repeating at home the experiments performed by Dr. Crawford, in illustration of his lectures on chemistry. He was entrusted with the sick pensioners under the charge of his parent, and permitted by the rest of the physicians and surgeons to attend many of their patients, who were affected with rare and dangerous diseases. He accurately examined the pharmaceutical plants, exhibited by Mr. George Preston; and availed himself of the means afforded by Messrs. Elliot, Drummond and M'Gill, the professors of anatomy, for observing the few occasional dissections which occurred in Edinburgh. The medical world, therefore, is much indebted for the valuable fruits produced by the subsequent labours of Mr. Monro, to the care with which the germs of his youthful mind were nurtured and developed by the combined assistance of his excellent father and the other distinguished practitioners in Edinburgh.

After completing the regular term of his apprenticeship, together with the usual studies in Edinburgh, he went to London in the year 1717, for the purpose of attending the lectures on experimental philosophy by Professors Hawksbee and Whiston, and the anatomical demonstrations by the illustrious Cheselden. It appears from the second edition of Mr. Cheselden's works, in 1726, that in consequence of Mr. Monro's communications, he had altered and improved almost *every part* of his anatomy. In London he was supplied with great opportunities for dissection, in which he acquired a dexterity and accuracy that laid the foundation of his future celebrity as an anatomist. The pupils of Cheselden were encouraged, by being allowed the use of his theatre, to form a society for mutual instruction, where they alternately gave lectures concerning the structure and uses of the different organs of the body; on which occasions young Monro frequently acted as demonstrator to his fellow-students. The ardour with which he pursued dissection in London endangered his life, by an attack arising from inoculation with morbid matter. He was also very industrious in forming anatomical preparations, which he sent to his father, by whom they were deposited in the museum of curiosities at Surgeons' Hall; and their great excellence induced Mr. Adam Drummond to promise his father, that if the future attainments of his son corresponded with such early exertions, he would, on the completion of his studies, resign the anatomical chair in his favour.

In 1718, he attended the hospitals in Paris, and the lectures of Chomel on botany and chemistry, of Gregoire on midwifery, Cessau on bandages, and those of Bouquet on anatomy. He performed, under the superintendance of M. Thibaut, the different operations of surgery, and was particularly attentive to morbid dissections.

In the autumn of the same year he repaired to Leyden, and became a pupil of the illustrious Boerhaave, who, having himself, twenty-six years before, derived much instruction and assistance in medical inquiries from Dr. Pitcairn, was enabled to return it with interest to this future ornament of Scotland, and distinguished improver of anatomical and surgical science. He carefully attended the lectures of Professor Boerhaave on chemistry, on the theory and practice of medicine, as well as his clinical lectures in the hospital. The study of comparative anatomy was also cultivated by him, and he pointed out its advantages to some of his fellow students.

The frequent opportunities afforded our young student of conversing with this eminent physician, in consequence of consulting him on important and novel cases from Scotland, convinced Dr. Boerhaave of the superior attainments and abilities of his pupil. His persevering application and study were clearly proved by the numerous MS. notes of lectures which he wrote.

This account of the labours by which the active mind of so great a benefactor of his country was enabled to stamp its own character on the rising generation of anatomists and physicians, must convince the most inconsiderate that no lasting attainments can be secured, without enlightened instruction, close application, and patient investigation.

His own observations and experience fully convinced him that dissection is the only method by which a correct system of the different branches of medical and surgical knowledge can be formed or improved. He also endeavoured, by maintaining and nourishing his favourite science from the common stock of natural philosophy, to promote its growth and vigour. Empiricism was thus prevented from continuing to maintain its influence, and truth enabled to acquire that ascendancy which it is entitled to claim.

Impressed with such views, young Monro, for he was then only twenty-two years of age, returned to Edinburgh in 1719, and succeeded, the following year, to the anatomical chair, on the resignation of Messrs. Drummond and M'Gill, at that time professors and demonstrators to the College of Surgeons, who thus testified the high opinion which they entertained of his qualifications, and fulfilled the promise made to his father. Soon after his appointment, he was induced to deliver a course of lectures on anatomy, and to illustrate them by his own preparations, made under the tuition of Cheselden and others.

The following fact affords a striking proof of his great abilities and self-possession as a public speaker. The unexpected presence of a large and respectable assembly, among whom were the Presidents and Fellows of the College of Physicians and Surgeons, who attended the first lecture, at the request of his father, not only disconcerted the professor, but deprived him of the recollection of what he had committed to memory. With a view to recal his scattered thoughts, he began to show some of his anatomical preparations, and determined at last to adopt such language as an intimate and extensive acquaintance with the subject might suggest. His great success on this occasion induced him to adhere, during the long course of forty years, to the same plan, and few lecturers ever surpassed him in ease, elegance and perspicuity of language.

Provost Drummond, a magistrate of a truly liberal and comprehensive mind, afforded young Monro every assistance, by means of his influence with the Town Council, and sanctioned the plan of teaching which he had adopted, by frequent attendance on his lectures.

The anatomical school of Edinburgh, established on such a firm foundation, and conducted by so able a professor, soon rivalled the university of Leyden itself, which had acquired the greatest celebrity from the exertions of the distinguished Boerhaave. Mr. Monro added much to the riches of Edinburgh, since his lectures were attended by 3850 students, who must have spent, on the most moderate calculation, the sum of £192,500. This fact affords the strongest proof of the uncommon success of his lectures, which were conducted in the following manner. After giving a view of the history of the science, examining the structure of the bones and the different parts of the body in a state of health, as well as the analogous organs of the inferior animals, he illustrated the whole by reasonings, calculated to point out the nature and character of the healthy functions, which he applied to the elucidation of disease and the improvement of surgery.

A hospital was still wanting, where the intimate connection between anatomy, surgery and medicine might be shown, and his father used every exertion to complete a plan on which the prosperity of the rising school depended. Mr. Monro himself also wrote a pamphlet, pointing out its advantages. The sum of 2000*l.* was, after some time, collected, and a temporary hospital erected in 1729, which was superseded by the present one, whose foundation was laid in 1738. Some of the principal rooms, particularly that for operations, were constructed according to a plan of the professor. By the mutual co-operation of all classes of citizens, this useful building, which is capable of holding nearly 300 patients, and open for the reception of the sick of all nations, was completed in a shorter time than could have been expected.

Provost Drummond was appointed by the first contributors to superintend, in conjunction with Mr. Monro, the erection of the hospital. In this spacious building the pupils of our professor learned to adopt humane and feeling manners towards their patients, while they were instructed in the best mode of curing diseases. He never absented himself from any dissection; and in all instances of death, whether from accident or disease, he not only pointed out to the students the difference between the healthy and morbid appearance of the various organs, but carefully explained the practice which had been adopted. The intimate acquaintance which he possessed of anatomy, and his knowledge of a vast variety of cases, enabled him to perform surgical operations with success, and gave him great superiority as a consulting physician and surgeon. He manifested his deep sense of the utility of clinical lectures, by continuing them with unwearied industry, after that disease had begun which terminated his useful career.

Mr. Monro assisted in establishing a society of physicians and surgeons, and six volumes of medical essays and observations were published by him as secretary, which he considered to be the best means of increasing the knowledge of medicine; and when, at the recommendation of Colin Maclaurin, the society was enlarged by the admission of philosophers as members, he contributed several valuable papers to the two volumes which were published during his life by the Philosophical Society, under the title of Physical and Literary Essays.

His conduct to Dr. Martin, private lecturer on anatomy at Edinburgh, exhibits a liberality of sentiment deserving of imitation, since he acted towards him with the greatest kindness while living, and undertook to superintend the publication of his works on anatomy after his death.

Dr. Monro has rarely been surpassed as a man of business, and he obtained great influence over his fellow citizens by his extemporaneous eloquence. He was a director of the Bank of Scotland, a justice of the peace, a commissioner of the high roads, and a manager of many public charities, and fulfilled the various duties which such situations require with great regularity and honour.

He was a steady supporter of civil liberty,—firmly attached to the House of Hanover, and manifested great attention and humanity to the wounded officers and soldiers who fell at Prestonpans. He evinced great compassion and benevolence to the rebels, not only by procuring pardon for them, but by cheerfully affording professional aid, which was of great use to those who had suffered in the army of the Pretender. His friendship with Colin Maclaurin, the friend and commentator of Newton, who was appointed professor in the year 1725, when Dr. Monro delivered his first lecture in the University, affords a strong testimony of the esteem and affection in which he was held by his intimate acquaintance.

Mr. Monro's influence as a teacher was much increased by the exterior graces of a well-formed person and gentle manners, which were combined with an amiable disposition, and the ennobling dignity of a comprehensive and liberal mind. It was his great object to perform professional duties with a spirit of true philanthropy, endeavouring to make his own experience subservient to the knowledge of others, as well as to the advancement of the healing art. He endeared his patients by an affectionate conduct, and his charitable attention to the wants and diseases of the poor secured their regard and esteem.

He performed the duties of a son, a husband, and a father in the most exemplary manner. His father, to whom Edinburgh is much indebted for her prosperity, died in Berwickshire, at the seat of his only son, whose success as a professor had contributed to gladden his declining years. He was very attentive to the education of his sons, instructed them in many of the sciences himself, and treated them through life with all the familiarity of a friend.

Dr. Monro frequently laboured under a spitting of blood when he caught the least cold, and was subject to inflammatory fevers. After an attack of the influenza in the year 1762, he was severely afflicted with a fungous ulcer of the bladder and rectum, which he bore with great patience and Christian resignation, and died with uncommon composure on the 10th of July 1767, at the age of seventy.

The works of Dr. Monro were published after his death by his son Alexander, professor of anatomy, in one 4to volume. The luminous order, and accurate philosophical description which characterize his writings, have secured him the admiration of all succeeding anatomists. His Osteology, the outlines of which were first read to a medical society, when he was student in London, is yet unrivalled. The methodical and simple arrangement that he has adopted in this work, must continue to be a model for every interpreter of nature, who wishes to follow her direction and not his own imagination. After showing the situation, general appearances, and divisions of the bones, he points out the connection of the one he examines with those around it, and concludes by enumerating the purposes which the bone serves in the animal economy, and stating its diseases. The Introductory Letter to the first edition of his Comparative Anatomy, is an able defence of this important branch of science. His Comparative Anatomy is excellent; and nothing affords so striking a proof of the range of Monro's mind, and the correctness of his reasoning, as the intimate union he assisted in establishing between comparative and human anatomy, from which he endeavoured to deduce his physiological observations. It clearly appears from his papers on medicine and surgery, that he was amongst the first, who, by conducting manual operations according to the light of science, assisted to rescue surgery from barbarism and ignorance, and to restore it to that rank and estimation which so useful a part of the medical profession is fully entitled to claim. His last work on inoculation in Scotland, written at the age of sixty-eight, evinces with what eagerness he continued to promote improvements in medicine, and to check the progress of prejudices injurious to the health, the comfort, and the lives of his fellow-men.

See *Life of Dr. Monro*, Primus, *prefixed to his Works*; Dr. Duncan's *Account of his Life*; Bowers' *History of the University of Edinburgh*, vol. ii. p. 166—188; Dr. Barclay's *Preface to a Series of Engravings, representing the Bones, by* Edward Mitchel, Engraver, Edinburgh; and *The Medical School of Edinburgh.*

ALEXANDER MONRO, *Secundus*, M. D. the youngest of the three sons of Dr. Alexander Monro, *Primus*, and Isabella M'Donald, second daughter of Sir Donald M'Donald of M'Donald, in the Isle of Sky, Baronet, was born at Edinburgh on the 20th of March 1733. He acquired the first rudiments of classical literature under Mr. Mundell, a distinguished teacher in Edinburgh, whose kindness and exertions were long remembered by his grateful scholars. His father, from a deep conviction that an intimate acquaintance with the principles of mathematical, physical and ethical knowledge, is the best preparation for medical enquiries, placed him under the tuition of his bosom friend, Colin Maclaurin, the Professor of Mathematics, Dr. Stewart, and Sir John Pringle. He did not commence the study of medicine under his father before he had attained his eighteenth year, when an enthusiastic diligence and ardour soon made him a useful assistant in the dissecting room. It was here, like Cheselden, Haller, and Albinus, that he obtained an accurate acquaintance with the structure and functions of the human body by constant dissection, the only sure basis on which medical and surgical improvements can be founded.

He studied the various branches of medicine under Professors Rutherford, Sinclair, and Alston, and prosecuted his labours with such unremitting perseverance, that in the year 1753, at the age of twenty, he assisted his father in his anatomical lectures.* He graduated in 1755, when his inaugural dissertation, *De Testibus et Semine in variis Animalibus*, displayed a minute knowledge of the physiology of these organs, and of the lymphatic system, which he afterwards investigated with so much success. His superiority as a demonstrator and lecturer induced the patrons of the University, in consequence of a petition from the father, to appoint him Professor of Anatomy and Surgery, on the 12th July 1755, and in the twenty-second year of his age.

Dr. Monro, *Primus*, manifested great solicitude in

* Dr. Monro, *Primus*, graduated after his son.

procuring testimonials, not only from the different professors, but also from such students as attended the demonstrations of young Monro, with a view to satisfy the patrons, in the most effectual manner, of his son's diligence and talents.

When Dr. Monro, applied, on this occasion, to the Town Council, and presented the testimonials of his son's character and abilities, Mr. Stuart, son-in-law of the former professor of anatomy, Mr. Drummond, and senior magistrate during the absence of Provost Drummond, at that time in London, told him, "he had no need or wish to inspect them. Tell me," said Mr. Stuart, "your own sentiments of him; for I am sure every one will trust you rather than any other person." "As you refer to me, then," observed the Professor, "you may believe me when I say, that if the world gives me credit for any ability or effect in promoting the character and usefulness of the University, I think more highly of him than they can think of me." He seems also to have been induced, by an anxiety for the prosperity of the College, to select as a professor the younger son in preference to the elder, from a conviction that the natural and acquired attainments of the former were better calculated to maintain the honour of the University than those of the latter.

Dr. Monro, *Primus*, being yet in the vigour of life, and an enthusiastic teacher of anatomy, sent his son to prosecute his studies under the most eminent professors at London, Paris, Berlin, and Leyden. Whilst the pupil of the celebrated Professor Meckel at Berlin, he resided in his family, and thus enjoyed all the advantages of public and private instruction. In 1758, Dr. Monro published at the same place his *Essay de Venis Lymphaticis Valvulosis*, for the purpose of proving, more at large than in his Thesis, that the valvular lymphatics are one general system of absorbents. The first preparation of the Acoustic Nerve, and the most minute ramifications of the lacteals, were made by him during his residence with Dr. Meckel.

He remained only a short time at Leyden, as Albinus, whose lectures he wished to attend, was confined with disease. This university, only 20 years before, had been justly considered the luminary of the medical world, but its splendour was eclipsed by the removal of the celebrated Albinus, Professor of Anatomy, and by the neglect of the patrons of the university to secure lecturers of distinguished ardour and intelligence. The genius and fame of Meckel had raised Berlin to the honourable rank which Leyden so recently possessed, and brought students from every quarter of the globe, to enrich that capital with science and wealth.

Dr. Monro returned to Edinburgh in the summer of 1758, where he was admitted a licentiate of the Edinburgh Royal College of Physicians on the 2d May, and elected a fellow on the 1st May, 1759. He also succeeded his father as secretary to the Philosophical Society. In the autumn of 1758, he commenced his lectures as colleague with his father, and combined in his own person the knowledge of some of the most celebrated anatomical professors of the last century, Cheselden, Boerhaave, Monro and Meckel. We need not be surprised to find the fame of the University of Edinburgh constantly increasing under a lecturer enriched with the treasures of such eminent anatomists, directed by the constant instruction and superintendance of his own parent, and whose ardent enthusiasm was regulated by the dictates of a comprehensive judgment and acute discrimination. His course of anatomical lectures was arranged nearly according to the same connected and orderly plan with that of Monro, *primus*, who continued to witness, during the space of nine years, the uncommon success of his son in the advancement of that instruction which he had begun. The demonstrations of our professor were conducted with a simplicity, accuracy and distinctness, which never failed to instruct and delight his students, and few men surpassed him in exciting a taste for that branch of science which he so ably communicated. The number of pupils who attended his lectures was 14,000, averaging nearly 350 annually. If, with Dr. Monro, *primus*, we calculate the expense of each student at 50*l.* per annum, the riches introduced into Edinburgh by the lectures of his son would amount to 700,000*l.*; and these two distinguished individuals may be considered as having added 892,500*l.* to the improvement of Edinburgh and its inhabitants.

A controversy was maintained with great warmth, betwixt Dr. William Hunter of London and Dr. Monro, on the subject of their respective claims to the discovery of the use of the lymphatics, which contributed to make both examine this part of anatomy with greater minuteness; and to their rivalship we are indebted for the intimate knowledge of that beautiful system of vessels, by which their office as absorbents is established with a certainty and clearness that remove all doubt.

The following statement by Dr. William Hunter, in his treatise on Aneurism, in the 6th volume of *The London Medical Observations and Enquiries*, affords a striking proof that he did not suppose the solid parts of the body were taken up by the lymphatic vessels.—"In this case (Aneurism) the appearance was rather as if the blood had insensibly *dissolved and washed away the substance of the bone*, as we see in stones of unequal texture, that have been long washed by a dropping, or a stream of water."—See Dr. Winterbottom's Thesis, *De Vasis Absorbentibus*, 1781, who gives a full account of Dr. Monro's opinion respecting the absorption of solids.

Dr. Monro's lectures are universally acknowledged to have been the fullest course of anatomy, physiology, pathology and surgery ever delivered. Dr. William Hunter was surpassed by none as a demonstrator or lecturer, but he paid too little attention to physiology, and on this account Dr. Monro, who for 40 years performed the arduous duties of the anatomical chair without an assistant, is entitled to greater praise than his powerful rival. He delivered his lectures until the year 1800, when his son, the present Professor of Anatomy, who had been conjoined with him in 1798, began to assist him. He continued, however, his surgical course until the year 1807, and delivered the introductory lecture for the session 1808-9, when he was 76 years old.

By a happy union of anatomical and medical knowledge, Dr. Monro was distinguished as a consulting surgeon, and displayed uncommon acuteness, correctness, and humanity in the direction of operations; and in surgery, to make use of the words of a very competent judge, Mr. B. Bell, "his improvements were numerous and important."

Dr. Monro commenced the practice of a physician on his return from the continent; and his skill and success have seldom been equalled by any practitioner in this city. For the attainment of so high an honour, he was indebted, in no small degree, to the habit of keeping a regular account of every case which came under his care, with the addition of such notes and observations as his good sense and accurate judgment supplied. His great object was to have recourse to simple and powerful remedies, whose efficacy was sanctioned by just reasoning, or extensive experience. With a mind uninfluenced by the dogmas of particular sects or parties, he was always prepared to adopt such new modes of practice as his increasing knowledge approved; and to accommodate his prescriptions to the various changes of diseases, which habits of accurate observation enabled him to discern. Few practitioners were more alive to the condition of a patient than our distinguished physician, who investigated their complaints with a caution and feeling that showed deep interest in the afflictions of the sufferer. This conduct inspired a confidence in his attentive kindness, which frequently promoted the recovery of those entrusted to his care.

As a consulting physician, Dr. Monro merited the highest praise. He entered into no subtle disquisitions or controversies about difficult or disputed points; he showed no credulity as to the virtues of particular remedies, nor did he arrogate to himself any superior skill, by boasting of his own success, but was always prepared to propose or adopt such active remedies as promised to be of essential benefit in difficult cases.

The celebrity of our Professor extended his fame throughout Europe, and he was admitted a member of the royal academies of Paris, Madrid, Berlin, Moscow, &c.

His favourite amusement was horticulture, which he pursued with much pleasure during the greatest part of his life.

Our Professor, in the midst of his other numerous labours, did not neglect to attend to his duties as secretary of the Philosophical Society, whose essays he continued to publish during the flourishing period when Lord Kames was president, and Sir George Clerk, Mr. John Clerk, Drs. Cullen, Home, Hope, Black, Young, Duncan, Hutton, &c. were members. An excellent paper of his, concerning the effects produced by narcotics and stimulants on the nervous system, in the 3d and last volume of this work, throws considerable light on the use of this important part of the animal economy. The same volume also contains some valuable remarks on polypous tumours in the pharynx and œsophagus, and on the use of mercury in convulsive diseases. In consequence of the proposal of Principal Robertson and Professor Dalzell, the Philosophical Society was incorporated by charter, in the year 1782, into the Royal Society of Edinburgh, and Dr. Monro resigned the office of secretary: he still, however, continued an active and useful member, and enriched their transactions with some excellent communications on animal electricity and galvanism, and on the effects of the oblique insertion of muscular fibres.

Dr. Monro was not so tall as his father, but had the same amiable mildness of countenance, and manifested the same benevolent pleasure in promoting the happiness, or alleviating the wants and distresses of his fellow-men.

He pursued the study of polite literature with his usual ardour, and introduced into his lectures, in a very appropriate and judicious manner, the stores he had acquired. He neglected no opportunity of extending his acquaintance with every department of knowledge, as far as these studies did not interfere with his professional, civil, or social duties. His character as a husband, father, friend, and landlord, was distinguished for affection, tenderness, kindness, and generosity. In his temper he was cheerful and candid, lively in conversation, pleasing in his manners, and conciliating in his disposition.

At last, after devoting more than 60 years to the service of mankind, he was attacked by a slow and painful disease, which terminated an active and valuable life, in the 85th year of his age. Under long confinement, increasing feebleness, and the prospect of greater affliction, his patience and resignation were most exemplary, and together with great thankfulness for past blessings, he displayed a humble confidence in the mercy of Him by whom his sufferings were inflicted.

In 1783, Dr. Monro published observations on the structure and functions of the nervous system, and has traced, farther than any of his predecessors, the olfactory nerve, the nasal twig of the ophthalmic branch of the 5th pair, and the vidian branch of the superior maxillary nerve. By ascertaining that these nerves are distributed on the same membrane, he contributed to the discovery of the sense of smell residing in more nerves than former anatomists acknowledged. He has also extended our acquaintance with the smaller branches of the auditory nerve and the nerves of the teeth.

In 1785, he published an excellent work on the structure and physiology of fishes, showing that the absorbent functions of the lymphatic system exist equally in birds, fishes, and amphibious animals, as in men and quadrupeds. He has demonstrated, in his Treatise on the Brain, the existence of lymphatics in that organ, by filling them with a coloured injection. His pathological and surgical observations in this work are extremely valuable, and point out the communication between the lateral ventricles of the brain, the seat of the water in Hydrencephalus; and that the changes in the texture of the brain are proved to be the result of absorption. In his Treatise on the Eye, he has described the muscular structure of the iris, the nature and course of the retina, concerning which Morgagni, Winslow, Haller, and his father, held different opinions, and has endeavoured to establish, by experiments, that the oblique muscles of the eye-ball, and the orbicular muscle of the eye-lids, are the means by which the eye is adapted to objects at different distances. In his Treatise on the Ear, he has published the most full and accurate description of the human cochlea,—of the smaller branches of nerves distributed upon its several component parts, and supplied many new facts respecting the ear of the whale, skate, tortoise and angel fish. In 1788, he published a work on the Bursæ Mucosæ, which adds to his character as a good anatomist and profound pathologist.

Such were the lives of the two Monros, who contributed to extend the boundaries of medical science, by promoting the advancement of valuable discovery and improvement—to divide at first the honour of medical degrees between Leyden and Edinburgh,—and finally, to raise the metropolis of Scotland to the highest celebrity as a school of medicine.

See *An Account of the Life, Writings, and Character of the late Dr. Alexander Monro*, secundus, by Dr. Duncan, senior.

MONS, (MONTES HANNONIÆ,) a town in the kingdom of the Netherlands, and the chief place of the province of Hainault, is situated partly, on a hill, upon the river Trouide, which traverses it. The town is well built, and contains several good squares and streets. The principal public buildings and institutions are the Hotel de Ville, a large old building, with a fine steeple, erected in 1716, and situated in a square; the Government house, situated in a spacious market-place; the Chateau and its gardens; the ci-devant Abbey of Wantru; a large hospital, originally constructed by Vauban; a commodious foundling hospital; a gymnasium, with a good library. The churches are well built. The great church is a fine building, the side altar and chapel being formed of pure marble. That of St. Elizabeth occupies the site of an ancient castle, demolished in 1618, and said to have been erected by Julius Cæsar. The town is surrounded by an earthen mound and ditches; and, since 1818, its fortifications have been increased. The manufactures of Mons are woollen, cotton, linen, and lace. It possesses also iron founderies, and works for salt, pottery, oil, and soap, which, from its command of coal, and its communication with Paris by the canal of St. Quintin, it carries on to great advantage. Population 20,000. East Long. 3° 57′ 15″; and North Lat. 50° 27′ 2″.

MONSOONS. See Wind.

MONSTER. See Physiology.

MONTAIGNE, (Michel de) a celebrated French writer, was born at the Chateau de Montaigne, near Bergerac, upon the Dordogne, on the 28th of February, 1533. He was the third son of Pierre Eyquem, a man of rank and probity, who appears to have discharged the paternal duties with extraordinary care. Young Michel was awakened every morning by soft music, lest sudden excitation might injure his health; and a German domestic, unacquainted with the French language, taught him to express his first ideas in Latin. At the age of six years, he was sent to the College of Bordeaux, then conducted by the most celebrated preceptors in France, one of whom was our distinguished countryman, George Buchanan. Montaigne's knowledge of Latin, acquired in a manner so uncommon, was here of some avail to him; and though we may be allowed to doubt his assertion, that the masters 'were afraid to accost him,' the instructions of his nurse must have materially contributed to form that minute and extensive acquaintance with classical literature, and that strong tinge of Latinity, for which his writings are so remarkable.

After seven years occupied in such studies, Montaigne, with the view of becoming a lawyer, engaged in the requisite course of preparation; but his love of jurisprudence, and his progress in that science, appear to have been equally small. The Parliament of Bourdeaux seldom witnessed his official exertions; and after his elder brother's death, from the stroke of a tennis-ball, he gladly exchanged the advocate's gown for the sword of a country gentleman. A short time after, 1560, he married Françoise, daughter of a celebrated pleader, Joseph de la Chassagne; and, possessing the Chateau de Montaigne, which his father bequeathed to him in 1569, enjoying a competent fortune and domestic happiness, he had full leisure to combine rural and intellectual employment in the most suitable proportion. Study seems, however, to have attracted nearly all his attention; riding afforded a healthful and favourite exercise; he lived remote from the political quarrels which, at that period, distracted his country; and few avocations enticed him from reading, or committing to paper such reflections as that reading excited, in whatever order they occurred. Before the decease of his father, Montaigne had translated the Natural Theology of Raymond de Sebonde; and, in 1571, he superintended the posthumous publication of his friend, the Sieur de la Boëtie's works. He did not appear in the character of an original author till 1580, when the fruit of his meditations was published under the title of Essays, at Bourdeaux. Eight years afterwards, in a new edition prepared under his eye at Paris, the work was augmented by a third book, and many additions to the part already published.

In this singular production, Montaigne completely fulfils the promise of 'painting himself in his natural and simple mood, without study or artifice.' And though Scaliger might perhaps reasonably ask, "What matters it whether Montaigne liked white wine or claret?"—a modern reader will not easily cavil at the patient and good-natured, though exuberant egotism, which brings back to our view 'the form and pressure' of a time long past. The habits and humours, the mode of acting and thinking, which characterized a Gascon gentleman in the sixteenth century, cannot fail to amuse an enquirer of the nineteenth; while the faithful delineation of human feelings, in all their strength and weakness, will serve as a mirror to every mind capable of self-examination. But if details, otherwise frivolous, are pardoned, because of the antique charm which is about them, no excuse or even apology, of a satisfactory kind, can be devised for the gross indelicacy which frequently deforms these Essays; and as Montaigne, by an abundant store of bold ideas, and a deep insight into the principles of our common nature, deserves to be ranked high among the great men of his own original age, he also deserves the bad pre-eminence, in love, at once of coarseness and obscenity.

The desultory, careless mode, in which the materials of the Essays are arranged, indicates a feature in the author's character, to which his style has likewise a resemblance. With him, more than with any other, words may be called the garment of thought; the expression is frequently moulded to fit the idea, never the idea to fit the expression. The negligence, and occasional obscurity of his manner, are more than compensated by the warmth of an imagination, bestowing on his language a nervousness, and often a picturesque beauty, which we should in vain seek elsewhere.

From the perusal of those Essays, it is natural to infer, that the author must have studied men, not only in the closet but the world. Accordingly, we find, that Montaigne had travelled over France, entertained the King in his chateau, and more than once visited the court, where Charles IX. gratified him by spontaneously bestowing the collar of the order of St. Michel. After the first publication of his Essays, he did not long continue stationary. In this case, however, the desire of viewing foreign countries was but secondary to that of freeing himself from a nephritic disorder which had afflicted him for several years, and which, having no faith in physicians, he sought to alleviate by the use of mineral waters. With this intention he left home in 1581, and, attended by several of his friends, traversed Lorraine, Switzerland, Bavaria, and Italy. From the baths of Plombiere, Baden, and Lucca, he came to Rome, where, among other honours that awaited him, he received the freedom of the city, and soon afterwards received intelligence that his countrymen of Bourdeaux had elected him their mayor.* At the King's command, he returned from Italy to undertake this office; and his constituents signified their approbation of his conduct in it, by continuing his appointment for another two years.

The remaining portion of Montaigne's life was chiefly spent in revising his Essays. It was disturbed by the tumults of the League, and finally by the ravages of the pestilence, which compelled him for a short period to leave his home. One of his last journeys was to Paris, for the publication of his works; and during his return, he remained some days at Blois, to witness the proceedings of the States-General assembled there in 1588. He is said to have predicted to his friend, the famous de Thou, that Henry IV. would embrace the catholic religion, and restore peace to France.

But the use of mineral waters had not banished Montaigne's hereditary distemper; and his constitution, weakened by it, was unable to sustain the attack of an inflammation of the throat, which seized him in September, 1592. On the 17th of that month, the disorder had deprived him of the use of speech; but as his mental faculties remained unimpaired, he desired his wife, in writing, to send for certain of his neighbours, that he might bid them farewell. After the arrival of these persons, mass was said in his chamber. At the elevation of the host, Montaigne, with an effort, raised himself upon his bed, and, clasping his hands together, expired in that pious attitude. He had almost completed his sixtieth year.

The character of Montaigne is amply delineated in his Essays. On contemplating this picture, we are surprised to find the principles of a stoic incongruously mingled with the practice of an epicure; and the *pillow of doubt*, upon which, during the flow of health, he professed to repose, exchanged in sickness for the opiates of superstition. But notwithstanding these inconsistencies, it is impossible to avoid admiring the continued benignity and pensive gaiety which distinguished his temper. The amiableness of his private live is attested by the fact, that under the five monarchs who, during his time, successively swayed the sceptre of a kingdom torn with fanatical divisions, his person and property were always respected by both parties; and few, at an advanced age, can say, like him, that they are yet untainted with a quarrel or a law-suit.

His Essays have been abridged, translated, and given to the world in various shapes. The most valued edition is that of London, 1724, in which the original expressions are scrupulously retained, and ably illustrated by the notes of M. Coste. (T. C.)

MONTAGU, (Lady Mary Wortley) the eldest daughter of Evelyn Pierrepont, earl, and afterwards duke of Kingston, was born at Thorseby, in Nottinghamshire, about the year 1690. Though four years afterwards she lost her mother, the Lady Mary Fielding, daughter of William, Earl of Denbigh, her education was conducted with all the care which so promising a genius seemed to deserve. In addition to the usual accomplishments, she easily gained from the preceptors of her brother, Viscount Newark, a considerable knowledge of the Greek and Latin languages, to which she soon added French and Italian. The famous Gilbert Burnet, Bishop of Salisbury, is said to have guided and encouraged her more advanced studies; a manuscript translation of Epictetus, which she executed during a week, in the summer of 1710, yet bears the corrections of that distinguished prelate.

Whilst making acquisitions, at that period so rare among persons of her sex and rank, the young lady continued principally at Thorseby, or at Acton, near London. In these narrow circles her liveliness and spirits were already no less remarkable than her learning. Mrs., or as we should now say, Miss Ann Wortley, daughter of the Honourable Sidney Montagu, seems to have been her most intimate associate; and this early friendship gave rise to her acquaintance with a son of the same nobleman, Edward Wortley Montagu, to whom, after two years, she was privately married, on the 12th of August, 1712. The valuable, though not brilliant qualifications of this gentleman, were long exercised in Parliament, where his graceful manner and knowledge of business secured him considerable influence. At the period of his marriage, the fathers of both parties being alive, he could not offer his wife such an establishment as to permit her accompanying him to London during his political engagements: for the first three years of their union she lived chiefly at Warncliffe-lodge, near Sheffield. But, after the death of Queen Anne, in 1714, when Charles Montagu, who conveyed the intelligence of that event to George I. had been raised from the dignity of baron to that of earl Halifax, and farther created first lord of the treasury, that nobleman did not overlook the services of his cousin Mr. Wortley, who soon obtained the appointment of commissioner in the same department. The nature of his office placed him in connection with the court; and the appearance of Lady Mary, who now first visited that scene, attracted universal admiration. Her beauty and genius were praised, her conversation was coveted by the highest ranks of the nobility, and a more honourable tribute was paid to her talents in the esteem which she obtained from Pope and Addison.

The short-lived pleasures of such a scene had scarcely yet found time to lose their novelty, when Lady Mary was called to visit objects of a far more diversified and striking nature. In the summer of 1716, Mr. Wortley resigned his situation at the Treasury-Board, in consequence of an appointment to occupy the place of Sir Robert Sutton, Ambassador at Constantinople, who had been removed to Vienna, and directed to co operate with his successor, in endeavouring to terminate the war between the Austrians and Turks, which at that time raged with extreme violence. In the month of August Mr. Wortley left England, and his lady did not hesitate to accompany him in a journey, which, though tedious, and not without hazard, promised to offer such a field for observation and enjoyment, as great skill in modern languages, and considerable acquaintance with classical antiquities, rendered her well qualified to profit by. After leaving Holland and Germany, the embassy continued two months at Adrianople. Sultan Achmed III.,

* About fifty years ago, a manuscript account of this journey was accidentally found in the chateau which Montaigne inhabited. Being ascertained to be his composition, it was published in 1774. But neither the curiosity attached to every thing which bears the name of Montaigne, nor the learned notes of M. Querlon, are sufficient to make us relish the insignificant and often disgusting contents of a work, that seems never to have been at all intended for meeting general inspection.

whom they found here, is said to have shown a more frank disposition, and less solicitude about the Koran, than usually happens with a Turkish prince. To this circumstance it is generally ascribed, that Lady Mary was enabled to augment her acquaintance with eastern manners, by an examination of the Haram, never before or since permitted to any European.

The knowledge which she gathered respecting the habits and character of this people was minute, her mode of communicating it lively and entertaining. But Europe, in general, owes to her residence in Turkey a much more solid advantage than any such entertainment. Whilst passing the summer months at Belgrade, not far from the shore of the Bosphorus, Lady Mary had occasion to observe a custom practised by the peasants, which was said to guard them from the effects of small-pox, a dreadful, and, at that time, cureless malady. She examined the process of ingrafting, or inoculation, as it was afterwards called, became convinced of its efficacy, and with a courage for which humanity is deeply indebted, she consented to have the operation tried upon her son, at that time about three years old. Edward Wortley Montagu, afterwards so celebrated for his rambling, eccentric character, sustained the experiment, without hurt, in the month of March, 1718. The event encouraged his mother to form the hope of establishing a practice so salutary in her own country. It is well known that, after a lapse of some years, the zealous support which she bestowed on the attempts of Mr. Maitland, her physician, to introduce inoculation, on his return to England, was at length crowned with success. In 1721, government allowed five criminals to avoid the sentence of death, by submitting to this process; the successful experiment was sanctioned by the College of Physicians; inoculation obtained the patronage of the Royal Family, and had finally triumphed over all opposition, when, eighty years afterwards, the more precious discovery of Jenner promised entirely to extirpate the disorder.

Lady Mary was not long detained from the society of her friends in England. Mr. Wortley's conduct was approved of both by the Courts of St. James and Vienna; but, owing to the exorbitant demands of the latter, his negotiations entirely failed. His letters of recal, countersigned by Addison, are dated 21st October, 1717; and on the following 5th of June, he and his family commenced their journey to Britain, where, after visiting Tunis, Genoa, Lyons, and Paris, they arrived on the 30th of October, 1718.

At the Court of George I., Lady Mary was received with increased distinction. The celebrity arising from her travels, the fund of new ideas acquired in the course of them, the graphical and spirited mode in which she described what she had seen, gave a new charm to her already fascinating conversation. She obtained particular notice from the Princess of Wales, afterwards Queen Caroline, and by her brilliant acquirements excited the praise or the envy of every competitor for such honours as the admiration of a court can bestow. The excellence of her sprightly conversation had already been stamped by the approbation of Pope; and at her return from Turkey, the poet appears to have manifested the continuance of that friendship which his lively, though rather affected letters, had so warmly expressed during her absence. He earnestly invited her to take up her residence at Twickenham, and had the pleasure of successfully negociating a lease of Sir Godfrey Kneller's house for her reception. In this celebrated village, Lady Mary could occasionally exchange the gaieties of fashionable life at London for the company of those celebrated characters who frequented the society of Pope, and diversify the flatteries of Dr. Young and her second cousin, Henry Fielding, by the conversation of Swift, Gay, and Arbuthnot.

But the friendship of wits is proverbially fragile. In the case of Pope and Lady Mary, its existence, rendered precarious by the conflicting claims of a vanity, which on both sides sought gratification in the dangerous province of satire, was shortened by political hostility. Dissatisfied with the quantity of praise which the world bestowed on Pope for correcting her productions, and which the poet, it was thought, did not steadily enough refuse, Lady Mary had for some time omitted consulting him on such occasions; and this coldness was increased at the accession of George II. by her avowed partiality for Sir Robert Walpole, and her intimacy with Lord Hervey, which could not but offend a professed follower of Bolingbroke. The publication of the *Town Eclogues* completed this alienation. Lady Mary had several years before submitted these poems to Pope's inspection, and as the satire or scandal they were supposed to contain rendered them an object of general curiosity, copies were extensively circulated, and to print them became a fit speculation for the noted Edmund Curl. In spite of remonstrances and threats, the work came out under Pope's name; and Lady Mary, defrauded of praise, and suspecting collusion, not only renounced all intercourse with him, but displayed the resentment of forfeited friendship in bitter sarcasms, which were too faithfully reported to the object of them. The irritable nature of Pope was little calculated to brook such treatment. His opinion of Lady Mary, under the name of Sappho, expressed in his satires with more rancour than taste or wit, called forth from his victim, and her coadjutor, Lord Hervey, also stigmatized under the name of Sporus, those "verses addressed to the translator of the first satire of the Second Book of Horace," the private circulation of which produced a letter from Pope to his antagonists, disavowing any such intention as the one imputed to him. Much has been said of the malignity displayed by Pope in this attack, and of the meanness with which he attempted to recede from it. Certainly the accusations brought against Sappho are of a character sufficiently black, and the author's equivocal statements about their application seem to argue considerable weakness of mind; but, if without investigating how far such accusations might be founded on truth, we condemn the man who, under the mask of a moralist, stoops to gratify his individual hatred, we are compelled at the same time to admit, that his antagonists appear to have wanted the power rather than the will, to be equally barbarous. It is matter of regret, that the friendship of Pope and Lady Mary was converted into enmity: but the means adopted by the one party to satisfy that enmity were hardly less blameable than those adopted by the other. A fierce, though dull execration of Pope's malice and deformity, is but awkwardly blended with censures of his virulence and coarseness.

The quarrel with this formidable satirist produced disagreeable results for Lady Montagu. It no doubt contributed to spread those black reports about her character and conduct, to which the many victims of her sarcastic pleasantry were at all times willing listners.

She still lived at court with the great and gay, sharing or directing their amusements, admired for the pungency of her wit, and the sprightliness of her occasional verses, but her life seems not to have been happy. To other sources of solicitude, ill health was at last added; and in 1739, with Mr. Wortley's consent, she resolved to fix her abode in Italy. Passing through Venice, where much respect was shown to her, she visited Rome and Naples, and after having spent several months at Chamberry and Avignon, she finally settled at Brescia. From this city, she afterwards removed to Lover, on the northern shore of the Lake Iseo, for the benefit of its mineral waters; where, having purchased and refitted an elegant house, she divided her attention between reading and managing the concerns of her vineyard. With a small and select society, she seems to have enjoyed more contentment in this retired situation than her former habits would have led us to expect. About the year 1758, however, she exchanged her solitude for the amusements of Venice, in which city she remained till 1761, the period of Mr. Wortley's death. She then yielded to the solicitations of her daughter, the Countess of Bute, and after an absence of twenty-two years, she returned to England in the month of October. But her health had suffered much, and a gradual decline terminated in death, on the 21st of August, 1762.

Overawed by Pope and his associates, Lady Mary had ventured to publish nothing during her lifetime. The Town Eclogues, above alluded to, were printed under Pope's name, and though his editors have continued to assign the "Basset Table," with the "Drawing Room," to him, and the "Toilet" to Gay, she seems, in fact, to have been the author of them all. Several of her other poems had appeared in different collections, but it was without her permission. If we may judge, however, from an expression employed in writing to her sister, the Countess of Mar, it would seem that Lady Mary contemplated the posthumous publication of her letters; and, towards the conclusion of her residence in Italy, she had actually transcribed that part of them which relates to Mr. Wortley's embassy. The manuscript, entrusted to Mr. Lowden, a clergyman at Rotterdam, was surreptitiously printed by Beckett in 1763; and the curiosity which it had long excited in the world, was finally gratified by the publication of all her poems and letters in 1803. The edition, undertaken at the request of her grandson, the Earl of Bute, was superintended by Mr. Dallaway, who prefixed to it a life of the author.

Concerning the merits of Lady Montagu's poems, it is not necessary to say much. Suggested chiefly by ephemeral topics, they seem to have been written without great care. They are not polished, but across their frequent harshness and infelicity of expression, we can easily discern considerable vivacity of conception, accompanied with some acuteness in discriminating character and delineating manners. It is to be regretted that they are not always free from indelicacy.

But Lady Mary's principal merit is to be sought for in her letters. Those written during the embassy were loudly applauded at first, and they have since maintained a conspicuous place in this still scanty department of English literature. The official character of Mr. Wortley procured her admittance to whatever was splendid or attractive in every country which they visited. She seems to have been contented with herself, and therefore willing to be pleased with others; and her cheerful, sprightly imagination, the elegance, the ease, and airiness of her style, are deservedly admired. Succeeding and more minute observers have confirmed the accuracy of her graphic descriptions. Her other letters are of a similar stamp. The continual gaiety, the pungent wit, with which she details the passing follies of a court, but too successfully imitating that of Louis XV., render her letters extremely amusing. In those written from her retirement at Lover, we discern the same shrewdness of observation, with a little more carelessness of expression. The pensive, calm regret which they breathe, and, above all, the tender affection for her daughter, the Countess of Bute, to whom they are generally addressed, perhaps more than compensate for the absence of that flow of spirits and exuberance of incident, which distinguished the correspondence of her youth. In a literary point of view, Lady Mary's writings certainly do not belong to a very elevated class, but they occupy the first rank in their class. Considering the times and the circumstances of the writer, they may safely be called extraordinary. And, though the general diffusion of knowledge within the last century has rendered it common for females to write with elegance and skill upon far higher subjects, Lady Mary deserves to be remembered as the first English woman, who combined the knowledge of classical and modern literature with a penetrating judgment and correct taste. (T. C.)

MONTAUBAN, a town of France, and the capital of the department of the Tarn and Garonne. It is situated upon elevated ground on the Tarn, which pursues a winding course beneath it, through meadows and woods. It consists of the old and new town, on the right bank of the Tarn, and of the Ville de Bourbon, on the left, the communication being made by a bridge of brick. The streets and houses are in general good. The square in the centre has good buildings of painted brick, with a double range of arcades. From this square eight streets diverge. The chief public buildings and establishments are, the cathedral, the bishop's palace, the ci-devant college of the Jesuits, an observatory, a society of arts and sciences, and a public library. The Protestant university, suppressed in 1629, was re-established by Bonaparte in 1810, and has four professors of divinity. The chief manufactures of the place are, silk stuffs, stockings, linens, serge, and woollen stuffs. From the elevated public walk, called the Falaise, there is a splendid view over one of the finest plains in France. The view extends to the distance of 30 leagues, and is terminated on one side by the sea, and on the other by the Pyrennees. Population of the town, 24,000, about half of whom live within the walls. The position of the observatory is in East Long. 1° 20′ 45″, and North Lat. 44° 0′ 55″.

MONT BLANC. See Blanc.

MONTESQUIEU, (Charles de Secondat, baron of) and likewise of la Brede, was born at the mansion-house of the latter estate, near Bordeaux, on the 18th of January, 1689. His father, at one time a soldier, had soon relinquished that profession: and young Montesquieu was early destined to the bar, from which his paternal grandfather and uncle had successively risen to the dignity of *president à mortier** in the parliament of their native province. His education was carefully attended to;

* Vice President. *A mortier* relates to the species of cap worn by that officer.

and the flattering presages of childhood being in this case followed by judicious management, were afterwards completely verified. On the 24th of February, 1714, he became an advocate in the parliament of Bordeaux; and the office of *president à mortier* in that court was consigned to him by the uncle already mentioned, on the 13th of July, 1716. He also inherited the property of that relation, who had lost an only son.

The new president sustained the reputation which his predecessor had acquired. His colleagues showed what opinion they entertained of his address and integrity, by charging him with the remonstrance, which they judged it proper to make, against the imposition of a new tax, during the minority of Louis XV. in 1722. This delicate task he successfully accomplished.

But the attainment of professional honour was not the chief object of Montesquieu's ambition. Following the instinctive bent of genius, he was unwearied in acquiring general knowledge; and his vigorous mind seems, at an early period, to have conceived the germ of those ideas, which he afterwards so brilliantly developed in his writings. Before the age of twenty, he had studied, with higher views than those of a mere lawyer, the voluminous works which treat of Roman jurisprudence: his regular abstract of their contents was probably the groundwork of the *Esprit des Lois*. But though already cherishing the hope of fame, he felt no impatience to show himself before the world. It was not till the age of thirty-two, that his first production, the *Lettres Persanes*, was given to the public in 1721, without the author's name. If the *Siamois*, of Dufreni, or the *Espion Turc*, suggested the plan of this work, its execution is entirely original. "The delineation of oriental manners," says d'Alembert, "real or supposed, of the pride and the dulness of Asiatic love, is but the smallest of the author's objects; it serves only, so to speak, as a pretext for his delicate satire of our customs; and for other important matters which he fathoms, though appearing but to glance at them." The work was generally read and admired; but some censures bestowed upon the conduct of Louis XIV. caused it to be regarded with an evil eye at Court; and one or two sarcasms levelled at the Pope awakened the zeal of such as were rigidly devout, or found it convenient to seem so. The author was industriously represented as a man equally hostile to the interest of religion and the peace of society. Those calumnies reached the ear of Cardinal de Fleury; and when Montesquieu, sustained by the public opinion of his talents, applied for the place which M. Sacy's death had left vacant in the French academy, that learned body was made to understand, that his majesty would never give his consent to the writer of the *Lettres Persanes*; because, though his majesty had not read the work, persons in whom he placed confidence had shown him its poisonous tendency. Without feeling too much anxiety for literary distinction, Montesquieu perceived the fatal effect that such an accusation might produce upon his dearest interests. He waited upon Fleury, therefore, and signified, that although for particular reasons he had not acknowledged the *Lettres Persanes*, he was very far from wishing to disown that work, which appeared to contain nothing disgraceful to him, and which ought at least to be read before it was condemned. Struck by these remonstrances, the cardinal perused the work; the objections were removed; and France avoided the disgrace of forcing this great man to depart, as he had threatened, and seek among foreigners, who invited him, the security and respect which his own country seemed little inclined to grant.* The 24th of January, 1728, is the date of his admission; and the inaugural discourse pronounced by him on that occasion appears to have been distinguished by that originality for which all his writings are remarkable.

A short time before this event, Montesquieu had quitted his judicial charge. Full of the important ideas which had long occupied his attention, he determined to renounce every engagement which might obstruct the perfection and publication of them. To qualify himself for the arduous task of investigating and appreciating the different political or civil constitutions of ancient and modern times, he judged it requisite to travel—that, so far as possible, he might study the manners and character, the physical and moral condition of the European nations, by actual inspection. In pursuance of this object, he set out for Vienna, along with Lord Waldegrave, the English ambassador. From this city, after conversing with the celebrated Prince Eugene, and surveying all that seemed worthy of notice, he passed into Hungary, and afterwards to Italy, where he met with Lord Chesterfield, and travelled in his company to Venice. Here he found our noted countryman, John Law, still fostering magnificent projects, though reduced to gain a precarious livelihood by often risking his sole possession, a diamond, at the gaming table. Whilst examining the singular institutions of this republic, and canvassing the subject with eager frankness in places of public resort, Montesquieu, being informed by a friend that the government took offence at his procedure, was cautioned to withdraw, if he wished to avoid a scrutiny which might be troublesome, and perhaps dangerous. He instantly embarked for Fucina, where he arrived in safety, though not till, in his fear of being overtaken by some gondolas which appeared to aim at reaching the ship, he had consigned his manuscript remarks to the waves.† He next visited Rome; and having surveyed Switzerland and the United Provinces, he repaired to this country in 1730. Newton and Locke were dead; but the philosophical traveller found men in England qualified to estimate his talents; respected and patronized by Queen Caroline, he enjoyed the intimacy of Pope, Bolingbroke, and many other eminent characters of that period.

From England, Montesquieu returned to La Brede. The striking scenes which he had examined, and the distinguished persons with whom he had associated, could not but furnish matter of deep and extensive re-

* Voltaire represents this matter in another light. "He (Montesquieu) adopted a skilful artifice to regain the minister's favour; in two or three days he prepared a new edition of his book, in which he retrenched or softened whatever might be condemned by a Cardinal and a minister. M. de Montesquieu himself carried the work to Fleury, no great reader, who examined a part of it: this air of confidence, supported by the zeal of some persons in authority, quieted the Cardinal, and Montesquieu gained admission to the Academy." *Ecrivains du Siècle de Louis XIV* § *Montesquieu*. The authenticity of this statement, however, appears to rest solely on Voltaire's evidence, not altogether unexceptionable in the present case. D'Alembert's account is generally preferred.

† In the *Dictionnaire Biographique*, this affair is said to have been a mere frolic, invented and executed by Lord Chesterfield, to convince Montesquieu of his error in maintaining that French *vivacity* was preferable to English *good sense*. But his Lordship's logic, as well as urbanity, must have left him, before he could make use of such an argument. The statement seems to be incredible.

flection to a mind so gifted. Perhaps his well known observation, that Germany is a country fit to travel in, Italy to sojourn, England to think, and France to live in, exhibits rather more pointedness than truth; but the practical knowledge which he had acquired respecting men and governments, was advantageously applied in his future productions. The first, in order of time, is an Essay, *Sur les causes de la Grandeur et de la Décadence des Romains*, completed during the two years of his seclusion at la Brede, and published in 1734.

In attempting to derive the grandeur and downfall of Rome from the admitted principles of human nature, Montesquieu gave a new turn to such investigations. If some elements of a problem so complex have been omitted, and others rated too high or too low, the work must be allowed to exhibit views of political society, at all times specious, often equally just and profound: the vivid pictures, the acute and original thoughts, with which it every where abounds, are to be traced in many succeeding speculations. It deserves praise also for the manly and liberal tone of feeling that pervades it.

But the chief basis of Montesquieu's fame is the *Esprit des Lois*, published in 1748. His profession had led him to examine the subject of law with great minuteness; and he appears, from an early period, to have aimed at discovering some system which might serve to connect the isolated facts of a science, the extent and confusion of which increased with his knowledge of it. Hitherto, writers on jurisprudence had limited their views to the codes of particular states, or to metaphysical discussions concerning the abstract rectitude of those codes. But the object of Montesquieu was different, and much more comprehensive. Embracing the various, and apparently capricious systems of law, as they regard commerce, religion, or civil rights, in every country which travellers or historians make known to us, he endeavours to elicit regularity from this chaos, and to derive the intention of each legislator, or at least the utility of his law, from some circumstances in the natural or political situation of those to whom it is addressed. The attempt, if not entirely successful, was arduous and vast: it was likewise altogether new. The reading alone which it presupposes would have deterred a man of common ardour; especially if, like the author, almost totally deprived of sight, he had been compelled to employ the eyes of others. But although the *Esprit des Lois* cannot be regarded as a full and correct solution, it is at least a splendid theory; and the labour of twenty years devoted to produce it, the enthusiasm required for sustaining such an effort, were by no means misapplied. The abundance of curious, and generally authentic information, with which the work is sprinkled, renders it instructive even to a superficial reader; while the vigorous and original ideas to be found in every page of it, by an attentive one, never fail to delight and astonish where they convince, and to improve even where the truth of them seems doubtful. The brilliant hints, correct or otherwise, which the author scatters round him with a liberal hand, have excited or assisted the speculations of others, in almost every department of political economy; and Montesquieu is deservedly mentioned as a principal founder of that important science. The merits of his work are farther enhanced by his style, which, though emphatic and perspicuous, rather than polished, abounds in elegant sarcasm, in vivid and happy turns of expression, which remind us of his countryman, Montaigne.

Among the defects of the *Esprit de Lois* may be numbered its want of method, partly apparent, partly real. The transitions are universally abrupt; the brevity sometimes degenerates into obscurity, and the smartness into affectation. Though the author's tone is always decided and positive, his statements and speculations are occasionally uncertain or erroneous: in particular, the effects attributed to climate (some of which may have been borrowed from Bodin's *Methodus Historiæ*) are greatly exaggerated. But whatever blemishes the work may have, it is entitled to the high praise of steadily supporting the cause of justice and humanity, without departing from the moderation and reserve proper in combating established prejudices.

The reputation which its author had already gained, procured for the *Esprit de Lois* a sufficient degree of attention; but the work, on its first appearance, was very unfavourably received. Such as were unable or unwilling to relish the deep philosophy of its matter, attached themselves to the blemishes of its manner, and affected to despise it. The Chancellor Daguesseau observed, that it should have been denominated *De l'esprit sur les lois*; and the pun obtained a circulation far above its merit. Voltaire also, being one day visited by the Abbé Olivet, whilst perusing the work, exclaimed, *Venez, L'Abbé, venez, lire Arlequin Grotius**. The general voice of Europe, indeed, soon put such criticisms to silence; but it was only to excite others of a graver and more dangerous nature. The Editor of the Gazette Ecclesiastique, long deeply engaged in the Jansenist quarrels which agitated France for many years, assailed the author of the *Esprit des Lois*, in two pamphlets, with the charge of deism, and the weightier, though contradictory one, of following the doctrines of Spinosa. The defence which Montesquieu published, admirable for its strain of polite irony, candour, and placid contempt, was entirely triumphant. Indeed, abilities of a much lower order than his, would have sufficed to cover with ridicule the weak and purblind adversary, who discovered the source of the *Esprit des Lois* in the *Bull Unigenitus*, and blamed his opponent for neglecting to examine the doctrines of grace and original sin. It is to be wished, that Montesquieu had employed means as legitimate to counteract Dupin's criticism. His admirers would willingly forget, that when a copy of this work, now ready for circulation, fell into his hands, he carried it to the royal mistress, Madame Pompadour, and allowed her to inform Dupin, that as the *Esprit des Lois* enjoyed her special favour, all objections to it must be instantly suppressed.

Some excuse for this part of Montesquieu's conduct may perhaps be found in the growing infirmity of his health, which rendered him daily less capable of enduring the vexation of such contests. In fact, the chagrin already produced by them, the effects of study, and the civilities of the great, who courted his society with an eagerness which he felt would be fatal, had

* This anecdote is reported by M. Suard, who had it personally from Olivet. If Voltaire really used the epithet in question, it must not be considered as expressing the deliberate opinion which that extraordinary person had formed of the *Esprit des Lois*; to the author of which, notwithstanding their mutual dislike, he pays a just and elegant tribute, in the discourse read at his admission into the Academy.

gradually undermined a constitution, at no time very robust. In the beginning of February 1755, he was seized with an inflammation of the lungs, which soon proved mortal. His last days were soothed by the sympathy of all ranks of men: and though loaded with the most cruel pains, far from his family, and insulted by the officious visits of Father Routh (an Irish Jesuit, who afterwards forged a letter in his name), the peace and equality of soul which had marked the tenor of his life did not forsake him at the close of it. He expired on the 10th of February, aged 66 years and a few days.

The private character of Montesquieu appears to have been such as the perusal of his works might lead us to anticipate. Possessing that calm independence which secured him respect, he possessed also that mildness and benignity of character which displayed itself in a cheerful temper, and obtained him universal love. He was distinguished by the readiness which he always manifested to use his influence with the government, in behalf of persecuted men of letters: and strict frugality frequently enabled him, without impairing the property of his family, to mitigate the wants of the indigent.

A multitude of anecdotes attest the extent of his colloquial powers. The number of nations and celebrated men whom he had seen, the vigour of his mind, its boundless fertility in original and lively ideas, rendered his conversation at once instructive and fascinating. It was curt, like his style, without bitterness or satire, yet full of attic salt, to which his Gascon accent perhaps added new charms. The frequent absence of mind, for which he was remarkable, never occurred in a serious or interesting discussion: it was not affected; and he constantly awoke from it by some brilliant sally fitted to revive the conversation. Though living with the great, and formed to delight the most polished circles, he could yet derive information and pleasure from the simplest objects, and felt at all times happy to exchange the splendid bustle of Paris for books and repose at La Brede. It must have been a striking spectacle to see this teacher of philosophers, seated beneath an oak in his pleasure grounds, and in order to relax his mind from the studies which he never carried to excess, conversing gaily with a crowd of peasants in their own patois, adopting their views, investigating their genius, supremely happy if his influence could terminate their disputes, or solace their troubles. His touching interview with the Marseillese artisan; his delight on learning that this young man devoted every evening to ply as a boatman for the ransom of a father captive in Barbary; his generous and delicate reward of such affectionateness have been made the subject of a drama entitled *Le Bienfait Annonyme*.

Montesquieu, in 1715, had married Demoiselle Jeanne de Lartigne, whose father, Pierre de Lartigne, was Lieutenant-Colonel in the regiment of Maulévrier. She bore him two daughters and a son. The latter, Jean Baptiste de Secondat, less noted for his respectable talents, than for the abstraction of his manners, wrote several tracts on commerce and natural history. He frequently resided in London, where some of his works were published. He died at Bourdeaux in 1796, aged 80 years.

Besides the works above enumerated, Montesquieu is author of the *Temple de Gnide*, which quickly followed his *Lettres Persanes*. The *Pensées Diverses*, collected from his manuscripts, was published in 1758; the *Lettres Familières* in 1767. None of these productions are destitute of genius, but they cannot add much to the reputation of a man otherwise so distinguished. His works have all been translated into English. The best edition in the original language is thought to be that of Paris, 1796, 5 vols. 4to, or that of Bâle, 1799, 8 vols. 8vo. (T. C.)

MONTE VIDEO, a town of South America, in the province of Buenos Ayres, situated on a gentle eminence on the north side of the river Plata. The town occupies the whole of the promontory that forms the east point of the harbour. The houses, which are generally only one story high, with flat roofs, are built of stone and brick. The town having an elevated situation, and the houses being interspersed with gardens and trees, has a fine appearance from the harbour. The public buildings are, the cathedral, which is handsome; the town-house, and the prison, which are situated in the great square. There is a lighthouse on the mountain, which overlooks the town, and gives it its name. The town is defended by regular stone fortifications, which enclose the whole peninsula. The trade consists in hides, tallow, and dried beef. Coarse copper from Chili, in square cakes, is sometimes shipped here. West Long. 56° 14′ 38″, and South Lat. 34° 54′ 48″. For a full account of the history of the place, and of the province, see BUENOS AYRES.

MONTFAUCON, BERNARD DE, a celebrated French antiquary, was born at Soulage, in Languedoc, on the 17th of January, 1655. His parents, distinguished among the nobility of those parts, usually resided at the chateau of Roquetaillade, where he lived till the age of six years. His education was then entrusted to the *Pères de la doctrine Chrétienne* at Limoux, under whose direction his zeal and assiduity were rewarded by a suitable progress in classical learning. Before leaving the paternal roof, his taste for reading had attracted the notice of Pavillon, Bishop of Aleth, who predicted the young man's future eminence; and in this new seminary, the perusal of Plutarch is said still farther to have excited his enthusiasm. Yet the promises of that early age at first seemed likely to be disappointed. Montfaucon adopted the profession of arms, and the contemplation of classical antiquity was exchanged for active service in the wars of Germany, under Marshal Turenne. But the character originally impressed upon Montfaucon's genius, though obscured, was not obliterated: the death of his parents, the loss of his superior officer, inspired disgust at the military life; he quitted the regiment of Perpignan in 1675, after serving two campaigns (in which it does not appear that his conduct was marked by any thing but the fighting of a duel), and entered the congregation of St. Maur, where, having spent the necesssary period of probation, he assumed the habit of a Benedictine.

In that tranquil scene, his love of study revived in proportion to the abatement of melancholy; and his theological pursuits were mingled with the investigation of antiquity. The fruit of these researches was manifested in 1688, by the publication of his first original work, *La verité de l'Histoire de Judith*, which involved an account of the Median and Assyrian empires, and a critical dissertation concerning that history of the latter, which is commonly attributed to Herodotus.

The reputation for learning which this treatise acquired, enhanced by several compilations, and particularly by his edition of St. Athanasius' works, published ten years afterwards, procured him a favourable reception in the various parts of Italy, to which his love of antiquarian studies led him, in 1698. At Rome, he officiated as procurator of his order; the Pope and Cardinals were lavish in their attentions; and Montfaucon, during the intervals of his ecclesiastical functions, gave frequent and unequivocal proofs of the learning which he possessed, and was anxious to augment. It is related, that Zacagni, then sub-librarian of the Vatican, feeling his vanity wounded by the praise bestowed on this accomplished foreigner, laid several schemes to lower him in the public estimation. One day, whilst Montfaucon, among a crowd of distinguished persons, happened to be sauntering in the library, Zacagni, with affected politeness, requested the antiquary to favour him with the date of a Greek manuscript, which he spread out before him. Montfaucon replied, that apparently it was written about 700 years ago; his antagonist, with a triumphant sneer, desired him to observe the name of Basil, the Macedonian, written at the top; the Frenchman asked if it was not Basil Perphyrogenitus, later by 150 years; and as this, upon examination, proved to be the case, Zacagni retired with his manuscript, and thenceforth left the stranger at peace.

On his return from Italy, in 1702, Montfaucon published the *Diarium Italicum*, which, besides a learned account of the antiquities he had visited, was farther enriched by some ancient Greek and Latin treatises, now printed for the first time. It deserves to be remarked, that this work was translated into English about twenty years afterwards, by the noted Orator H nley, whose 'gilt tub,' and whose labours in it, as 'the Preacher and the Zany of his age,' have been immortalized in the Dunciad of Pope.

After the period of his return from Italy, Montfaucon's life was marked by nothing but the successive appearance of his writings. The *Paleographia Græca*, exhibiting rules to determine the age of Greek manuscripts, appeared in 1708; and his great work, *L'Antiquité Expliquée*, in 10 vols. folio, Latin and French, was published in 1719, and followed by a supplement of 5 vols. in 1724. The book (of which this edition is still reckoned the best) contains above 1200 plates; and though many of them are only copies of inaccurate originals, and though the whole seems to bear evident marks of haste, it was regarded as a very extraordinary effort, and continues yet to be a mine from which other less laborious inquirers draw their information. After the *Monumens de la Monarchie Françoise*, 5 vols. folio, came out in 1729, Montfaucon spent the rest of his life chiefly in revising his foregoing productions. Except the publication of his *Bibliotheca Bibliothecarum*, it was marked by no incident worth recording; and two years after that event, he died suddenly at Germain-des-Près, on the 21st of December, 1741.

Montfaucon was celebrated for the mildness and benignity of his character. Neither the favours which he had received from an emperor, nor the honours with which he was decorated by two successive popes, could at all abate his humility; and strangers who conversed with him, returned not more surprised at the amazing extent of his information, than at the unpretending simplicity of his manners. Of an author who has left 44 vols. folio, it may be expected that elegance will not be a characteristic; and, accordingly, Montfaucon's writings are blamed for their cumbrous style and defective arrangement; but his erudition, a quality more befitting such pursuits, has never been called in question; and his works are still looked up to, as guides through that obscure and intricate department of knowledge which he devoted his life to study. (T. C.)

MONTGOMERYSHIRE, an inland county in North Wales, on the north touches on Denbigh and Merionethshires; from the former, it is in part divided by the river Tannatt; on the south, it is bounded by Radnorshire; on the west, by Merionethshire and Cardiganshire; and on the east, by Shropshire. It measures in length from north to south about 35 miles, and in breadth, from east to west, 30 miles. It is the largest county in Wales, measuring, according to Templeman, 444.800 acres; and, according to Evans, 491,000 acres. Of these, only 60.000 are arable, 180,000 are under pasture, and the rest are in a great measure waste and uncultivated. It is divided into nine hundreds, and contains 47 parishes, and seven market towns, viz. Montgomery, a borough, and the county town; Welspool, Llanfyllin, Llanfair, Machynleth, Newtoun, and Llanydloes. It returns two members to Parliament, one for the shire, and one for Montgomery; is in the province of Canterbury, and dioceses of St. Asaph, Bangor, and Hereford.

This county possesses a larger proportion of fertile vales and plains than most of the Welsh counties. The vale through which the Severn flows, is by far the most considerable, and in general the most fertile; there are likewise smaller, though equally fertile vales, through which several of the tributary streams of the Severn flow. The greater part of the county, however, is mountainous, and the mountains are in general very bleak in their appearance, as well as sterile. A chain, commencing at Plinlimmon, in the south-west, and running north-west, with some deviations, till it terminates in the vale of Festiniog, may be called the back-bone of this county and Merioneth. Nearly 50 miles of this chain might be traversed without crossing a single stream; and a farm-house on it is so situated, that the rain which falls on the west side of the roof, flows into Cardigan bay, while that which falls on the east side, flows into the sea near Chester. The main streams on the west side of this chain, are the Dovey, the Maw, and the rivulet that flows through the valley of Festiniog; on the east side, are the sources of the Wye, Severn, Dee, &c. The Wye rises on the south side of Plinlimmon, and taking an east, and afterwards a south-east course, leaves the county. The Severn soon loses its character of a mountainous stream, forming large valleys, and generally flowing between deep banks. At Llanydloes, it ceases to be a torrent, and thence forms a delightful valley; as it inclines near Montgomery to the north, the valley expands, and it soon afterwards enters Shropshire, near the Brythen hills. Of the streams which join the Severn in this county, the largest are the Fyrnwy and Tannatt. The former is composed of two uniting branches of the same name, which cross the county from the west, and join the Severn near Llandrinio. The Tannatt meets it before its junction with the Severn. This latter is of the greatest importance as a navigable river, as it has a conveyance from Montgomeryshire into South Wales, through Shropshire, Worcester, and Gloucester, to Bristol. Plinlimmon has been incidentally mentioned: it lies partly in this county, and partly in Cardiganshire, belonging, however, more properly to the latter. Its perpendicular height is far inferior to that of Snowden and Cader Idris, and it is indeed a very dreary spot. The view from its summit, however, is very extensive, and in some points very grand. There is one canal in Montgomeryshire, which begins at Portymain limeworks, in Shropshire, where it unites with the Ellesmere canal. It afterwards crosses the Fyrnwy, and joins another part of the Ellesmere canal. There is a cut to Welspool, and from thence it goes parallel to the Severn, till it joins it at Newton. It is 27 miles long, besides the cuts, and the lockage is 225 feet. The soil of the valleys is principally a strong loam; that of the mountains a thin and cold clay. Limestone is only found at the termination of a ridge which runs from the north-west of Anglesey through Caernarvonshire and Denbighshire, and near the confluence of the Severn and Fernwy: on a limestone rock here, immense quantities of lime are burnt. The climate of this county varies considerably. The midland, west, and south-west parts, are very cold and ungenial, in consequence of their elevation; the climate of the valleys, and of the fine arable land that lies on the east side of the county, is mild. The strongest winds blow from the south-west and north-west. The west wind blows nine months in the year.

Montgomeryshire is rich in mineral treasures; the most important and abundant of which is lead. A considerable mine of this metal has been found at Dylipan, and another on the borders of Cardiganshire, near a copper mine, the ore of which contains much silver. An uncommonly rich lead mine was wrought many years with very great profit at Llangynnog, but it is now overpowered with water at the depth of 100 yards; it was discovered in 1692, and contained a solid rib 3½ yards thick of pure ore, affording for forty years a clear annual revenue of £2000; yielding about 4000 tons annually. There are still, however, obtained in this neighbourhood considerable quantities of lead and calamine, which are sent in their raw state to the foundries near Ruabon in Denbighshire. From the lofty rocks of Llangynnog, a considerable quantity of coarse slates is obtained. It is remarked, that the strata of these and other quarries which lie on the north side of the mountains incline to the east, while in those to the south, the ore is reversed. Slate is also procured near the junction of the Fyrnwy and Severn, and sent down to Bristol. Coal is found only at Coadwaes, on the borders of Shropshire: it burns rapidly. The Severn and its tributary streams are celebrated for the great varieties of fish which they contain; it is said that the salmon penetrates up the Severn almost as far as Plinlimmon. This county was once well covered with trees, and is still well wooded; its oak has been preferred to all others for the use of the dock-yards; in the year 1796, three oaks were cut down, which measured respectively 525, 450, and 687 cubic feet.

The agriculture of this county presents little that is interesting; in some of the vales a good system of arable husbandry is followed; in the east part of the county hemp is much grown. Few cattle are fattened; the genuine breed are bad; the best sheep are peculiar to the Corry hills; their wool is tolerably fine. The hilly tracts are almost entirely sheep-walks; "and the flocks, like those of Spain, are driven from distant parts to feed on them during the summer; the farms in the small valleys being only a sort of appendages for winter habitations and provisions." A horse peculiar to the hilly parts of this country and Merionethshire, is a small poney called myrlyn; they are very hardy and active, and well adapted for the team upon mountainous farms. The roads are far from good; from the returns to Parliament it appears that, in 1814, the length of the paved streets and turnpikes was—

	Miles.	*Furl.*
	356	2
Length of all other turnpikes, . .	964	6
Total,	1321	0

The estimated value of the labour on them,	£4231	0	0
Composition money, ...	429	0	0
Highway rates, ...	568	0	0
Law expenses, ...	39	0	0
Total,	£5267	0	0

The principal manufactures are flannels, and other coarse cloths; the principal manufactories for flannels are within twenty miles round Welspool; at this town a large quantity is sold annually, chiefly the produce of manual labour, though latterly about forty carding and several spinning-machines have been erected. The flannels of this county are from 100 to 120, and some of them 132 yards long, and seven-eighths of a yard wide. They are sent from Welspool in a rough state to Shrewsbury, where they are finished. There is a great market for woollen yarn at Llanydloes. The following are the results of the returns relative to the poor for the year 1815:

Annual value of real property, .	£207,286	0	0
Poor and other rates, . . .	33.488	0	0
Expended for the poor, . . .	28,830	0	0
——— in law, removals, &c. .	1,958	0	0
——— for militia purposes, . .	81	0	0
Church rates, ...	2,927	0	0
Total expenditure,	£274,570	0	0
Number relieved out of work-houses,	3,887	0	0
——— in ditto, .	184	0	0
——— occasionally, .	1,319	0	0
Total relieved,	5,390	0	0
Donations for parish-schools, . .	£341	0	0
——— for other purposes, . .	497	0	0
	£838	0	0

The following are the results of the returns respecting the population:

Population in the year 1700 . . .	27,400
in 1750 . . .	37,000
in 1801 . . .	49,300
in 1811 . . .	51,931

One baptism to 36 persons; one burial to 63; and one marriage to 152 persons; this last is a smaller proportion than any other county in England or Wales, except Monmouth and Flint; the average of Wales is 122.

Houses inhabited, . . .	93,49
Families inhabiting them, . .	103,05
Houses building, ...	40
——— uninhabited, . . .	174
Families employed in agriculture,	6369
———— in trade, . . .	3164
All others, ...	772

Males,	. . . . . .	25,373
Females,	. . . . . .	26,558
	Total in 1811,	51,931
	in 1801,	49,300
	Increase in 1811,	2631

See Davis's *Agriculture of North Wales. Beauties of England and Wales*, vol. xvii. (w. s.)

MONTGOMERY, the county town of Montgomeryshire, is situated on the declivity of a hill, not far from the east banks of the Severn; it is governed by two bailiffs and a town-clerk, and returns one member to Parliament; the right of election is vested in the burgesses of the town only, who amount to about eighty; it is a small neat town. The castle was formerly a strong and majestic building; it stood on the extremity of an eminence on the north side of the town, the projecting rock being very high. During the civil wars, a general and hard contested battle took place near Monmouth, which terminated in the defeat of the royalists; soon afterwards the parliament ordered the castle to be dismantled. Till very lately Montgomery was nearly destitute of trade, but by means of its canal it now imports a vast number of various kinds of goods from Chester, and exports limestone, lead, slate, &c. The following are the population details for the year 1811:

Houses inhabited, . . .	818
Families inhabiting them, . .	924
Houses building, . . .	5
——— uninhabited, . . .	17
Families employed in agriculture,	591
——————— in trade, .	270
All others, ...	63
Males, ...	2295
Females, ...	2316
Total,	4611 (w. s.)

MONTPELLIER, MONS PESSULANUS, or MONS PESTELLARIUS, a city of France, and capital of the department of Herault, is finely situated upon a height, which it entirely covers. Its houses rise in the form of an amphitheatre, and the river Lez waters the rich plain on which it stands. The streets of the town are narrow, dark, and winding, and the squares are small, and few in number. The houses are in general black and gloomy, and the principal edifices, such as the palace of justice, the ancient bishop's palace, now the palace of the Prefecture, the hotel de ville, and the cathedral, are of a bad style of architecture. The fauxbourgs, which surround Montpellier, are nearly as large as the town itself, and conatin many good houses. The town is watered by a great number of fountains.

Montpellier is celebrated principally for its university, which was established in 1289, by Nicolas IV. who divided it into the three faculties of law, medicine, and the arts. In 1410, the faculty of theology was substituted for that of the arts. At the revolution, the university was abolished, and the faculty of medicine was established under the title of the Special School of Medicine. The school of surgery, founded by Lapeyronie, is now united with the school of medicine. During the ministry of M. Chaptal, a superb amphitheatre was constructed for it, on the model of the Museum of Natural History at Paris. The chair of the professor of anatomy is placed in a superb seat of marble, which was brought from Nismes more than 100 years ago. The library is only in its infancy. The botanic garden, which is the oldest in France, was instituted in 1598. There is also here a special school of pharmacy, and a well regulated hospital.

The old academy of sciences at Montpellier has been replaced by a literary society, called the Free Society of Sciences and Letters. There are also here a medical society, a society of practical medicine, and an agricultural society. An academy of arts, which distributes medals annually, was founded in 1781.

Montpellier contains several interesting cabinets, viz. that of the city, that of M. Lamoreux, which is very rich in rare shells; that of M. Marcel Serres, containing more than 9000 insects, and valuable minerals, and a considerable herbarium, belonging to M. Bouchet Doumeng.

The principal manufactures of Montpellier are those of brandy, perfumeries of all kinds, and verdigris, or acetate of copper. Corn, oil, silk, and wool, the productions of the neighbouring territory, are the principal sources of the commerce of Montpellier. Coverlets, handkerchiefs, and cotton cloths, are also manufactured here. These articles of trade are carried by the canal to Cette, which is the port of Montpellier.

The principal promenades of the city are, the Esplanade, the Peyrou, and the Canourgue. The Esplanade, begun in 1724, by the Duke de Roquelare, occupies the ground between the citadel and the ancient city. It is extensive, and shaded with rows of trees, and adorned with several large basins. The Place du Peyrou is situated on the highest part of Montpellier. The ground, supported by very high walls, forms two terraces, placed one above another. The lower one, which occupies the greatest space, is planted with several rows of trees, and adorned with two fine fountains. The wall of the upper terrace is surmounted with trophies. At the bottom of the place is the reservoir of water, which is supplied by the aqueduct, designed by M. Pitot, for conveying to Montpellier the waters of St. Clement. It has two rows of arcades, and the second supports a long gallery. This magnificent work is allowed to decay. The Canourgue is celebrated chiefly for being the place where Rousseau walked during his stay in that city. Population of Montpellier, 26,704. Its mean temperature is 59° 4′ of Fahrenheit. The observatory is situated in East Long. 3° 52′ 40″, and North Lat. 43° 36′ 15″. 47‴. For a full account of this town and its antiquities, see Millin's *Voyage dans les Departemens du Midi de la France*, tom. iv. chap. 114, 115, 116, p. 283.

MONTREAL, a town of North America, in Lower Canada, is situated on an island formed by the river Ottawas and the river St. Lawrence. The island is 32 miles long by 10 broad, and is very productive in all kinds of grain, vegetables, and fruits.

The town, which derives its name from a high mountain in the middle of the island, forms an oblong square, surrounded by a lofty but decaying wall. It is divided into the upper and the lower town. The old streets are narrow and gloomy, but the new ones are more open, extending parallel to the river, and crossed by others at right angles. Many of the houses are large and well built, of a greyish sort of stone, and in general are roofed with sheet iron or tin. The Place d'Armes, which is the only square, excepting the two market places, is situated on the side of the town farthest from the river, and was originally built for the purpose of military exercise. Montreal contains six churches, an Episcopalian, a Presbyterian, and four Roman Catholic churches. The cathedral church, which belongs to the Catholics, stands in the Place d'Armes. It is a spacious stone building, containing five richly decorated altars. The other public buildings and establishments are, the Hotel Dieu, for relieving the destitute sick, managed by a superior and 36 nuns; the convent of Notre Dame, for female instruction, managed by a superior and 60 nuns; the convent of the Grey Sisters and the Hospital of Invalids; the Seminary of St. Sulpice, for the education of youth; and the New College, which is a handsome building. The civil and criminal courts are held in a plain but neat building, in Notre Dame Street, and near it stands the jail, erected in a salubrious situation, on the site of the one which was burned down in 1803. The government house is an old and elegant building. The barracks, encircled with a lofty wall, and capable of containing 300 men, are agreeably situated near the river.

The harbour of Montreal is commodious: there are fifteen feet of water close to the shore, near the market-gate. Montreal is the great depot for the fur trade, of which we have already given some account in our articles CANADA and HUDSON'S BAY. The population of Montreal is stated, by Morse, to have been 16,000 in 1809, and by Gray to be 10,000, while others make it little more than 6000. For farther information respecting this place, see the works quoted under the article CANADA. West Long. 73° 35′, and North Lat. 45° 31′.

MONTROSE, a royal burgh, and maritime town in the county of Forfar, is situated at the mouth of the river South Esk, 70 miles north from Edinburgh, in 56° 34′ of north Latitude, and 2° 10′ of west Longitude from London. The ancient name of Montrose, according to Boece, was *Celurea*; but the etymology of its modern appellation has been variously resolved. In Latin, it is called *Manturum* by Ravenna; and by Cambden *Mons-rosarum*, "the Mount of Roses;" in French, *Mons-trois*, "the three hills or mounts;" in the ancient British, *Manter-rose*, "the mouth of the stream;" in the Gaelic, *Mon-ross*, "promontory-hill," or *Moin-ross*, "the promontory of the moss," or *meadh*, (pronounced *mu*) *an-ross*, "the field or plain of the peninsula." The second of these derivations, though the most unlikely of all, is countenanced by the seal of the town, which bears the ornament of roses, with the following motto, "Mare ditat, Rosa decorat;" but the two last, besides being the most probable, correspond best with the pronunciation of the name by the common people in the neighbourhood, and by all who speak the Gaelic language, viz. *Munross*.

The erection of Montrose into a royal burgh has generally been referred to the year 1352, the twenty-third of the reign of David II.; but there is every reason to think that the original charter must have emanated from David I. In the rolls of the parliament, which was held at Edinburgh, in September, 1357, for effecting the ransom of David II. from his captivity in England, the burgh of Montrose stands the ninth upon the list, with the names of eight other burghs behind it; a circumstance, which is scarcely compatible with the supposition of its having been created a royal burgh only five years before. It appears, at least, to have been a place of some note long before the earliest date assigned to its erection as a royal burgh; and is mentioned in Dalrymple's *Annals of Scotland*, among some of the principal cities of the kingdom which were nearly destroyed by fire in the year 1244. Its name is connected with many important events in Scottish history. It is mentioned by Froissart as the port from which Sir James Douglas embarked, in 1330, with a numerous and splendid retinue, on a pilgrimage to the holy land, carrying along with him the heart of Robert de Brus.* It is distinguished as the first place in Scotland where the Greek language was taught, by teachers from France, brought over by John Erskine of Dun, in 1534; and as having sent forth, from its seminary, the celebrated scholar Andrew Melville. It was the birth place of the warlike Marquis of Montrose; and the house in which he was born, was occupied as an inn not many years ago. It was the only town in Scotland, so late as the commencement of the eighteenth century, where a person could be found who understood the management of pumps in coal works, namely John Young, a citizen of Montrose, who had been sent over to Holland by the magistrates, for the purpose of learning the most improved modes of constructing and using windmills. It was the first port made by the French fleet, in December, 1715, with the Pretender on board; and that prince embarked at the same place in February of the following year. But one of the principal events of the history of Montrose regards an alteration in its own municipal constitution. The set of the burgh formerly consisted of nineteen members, seventeen as representatives of the guildry, and two as representing the seven incorporated trades. The old council elected the new; and the old and new elected the office-bearers. But the magistrates and council, upon the petition of the guild-brethren and the incorporated trades, granted to the former the election of their dean, who became *ex officio* a member of council; and to the latter the election of their two representatives in council; and this alteration in the set having been submitted to the convention of royal burghs for their approbation, was confirmed by them in July, 1816. In consequence, however, of an informality in the mode of electing the magistracy at Michaelmas following, the burgh was disfranchised by a sentence of the court of session; and, in answer to a petition from the inhabitants, a new charter, with an improved constitution, was granted by the crown, in the following terms: "That the town-council shall, as formerly, consist of nineteen persons, including in that number the provost, three bailies, the dean of guild, treasurer, and the master of the hospital; of which nineteen, fifteen shall be resident guild-brethren, and four shall be resident craftsmen, including the deacon-convener for the time: That, at the Michaelmas election, the six eldest councillors for the time from the guildry, who have not served in any of the offices after mentioned for the year preceding, and the whole four councillors from the craftsmen, shall go out, but shall nevertheless be re-eligible, if their respective constituents shall think fit: That, upon the Monday of the week immediately preceding Michaelmas, in each year, the magistrates and council shall meet, and declare the names of the six guild councillors who go out in rotation, and also what vacancies have arisen during the preceding years by death or otherwise, in the number of guild councillors: That, on the following day, being Tuesday, the guildry incorporation shall assemble at

* We have been indebted to James Burnes, Esq. the present provost of Montrose, for much curious information respecting the antiquities of the place, which we regret that our limits will not admit of our inserting at large.

their ordinary place of meeting, and shall first elect their dean of guild, and six members of the guildry, as his council for the ensuing year; and the person so chosen as dean of guild shall, in virtue of his office, be a magistrate and councillor of the burgh; and the said incorporation shall then proceed to fill up the vacancies in the number of merchant councillors, occasioned by rotation, non-acceptance, resignation, death, or otherwise, during the preceding year: That the seven incorporated trades shall also assemble together in one place on the said Tuesday, and shall first elect their deacon convener, who shall, in virtue of his office, be a councillor to represent the trades; and they shall then proceed to elect other three in the room of those who retire from office, and that two of the four trades-councillors to be so elected may be guild brethren, being always operative craftsmen, and the persons electing them shall have no vote in the guild in the same election; but the other two trades-councillors shall be operative craftsmen and burgesses only: That the council shall meet on the Wednesday immediately preceding Michaelmas, unless Michaelmas-day shall happen to be upon Wednesday, in which case they shall meet on Michaelmas-day, and conclude the annual election for the ensuing year, by continuing the *ex officiis* members, electing the two members of council, who do not go out by rotation, and receiving the new members from the guildry and trades; and, after such election, and receiving the new councillors, the members both of the old and new council shall, according to the formor set of the burgh, choose a provost, three bailies, a treasurer, and hospital-master; that the provost, bailies, treasurer, and hospital-master, shall not be continued in their offices longer than two years together; but they, with the dean of guild, shall remain *ex officiis* members of the council for the year immediately following that in which they shall have served in these offices respectively."

The town of Montrose stands on a level sandy plain, or peninsula, bounded on the north-east by the German Ocean, on the south by the river South Esk, and on the west by a large expanse of water, called the Basin, about eight miles in circumference. This basin, through which the South Esk flows into the sea, is nearly dry at low water; but is so completely filled by every tide, as to wash the garden walls on the west side of the town, and to afford sufficient depth of water in the channel of the river for allowing small sloops to be navigated to the distance of three miles above the harbour. At these periods of high water, the appearance of Montrose, when first discerned from the public road on the south, is peculiarly striking, and seldom fails to arrest the eye of a stranger: the basin opening towards the left in all the beauty of a circular lake; the fertile and fully cultivated fields rising gently from its banks; the numerous surrounding country-seats, which burst at once upon the view; the town, and harbour, and bay, stretching farther on the right; and the lofty summits of the Grampians, nearly in the centre of the landscape, closing the prospect towards the north-west—altogether present to the view of the traveller, one of the most magnificent and diversified amphitheatres to be found in the United Kingdoms. A handsome wooden bridge over the South Esk, (fully described in the Scots Magazine, Feb. 1817,) founded in 1793, about 700 feet in length, and one of the most remarkable structures of the kind in Great Britain, forms a fine approach to the town, with the harbour on the right, and the basin on the left. The river at this point is of considerable depth, about twenty feet at low water in ordinary tides, and thirty-five at spring tides; and so rapid, that it frequently runs at the rate of six miles an hour. On the west side of this entrance, and close upon the river, is the largest of the three mounts, to which the French name of the town is supposed to refer, called Forthill, on which a fortification was formerly erected, and in cutting through which, to form a new entrance to the town from the bridge, a stratum of human bones, nearly fourteen feet thick, was laid open. The harbour, on the east side of the bridge, is very commodious, and furnished with excellent quays. Two light-houses have been lately built, to direct vessels in taking the river during the night; and a large house, in which the keeper of the lights resides, is provided with accommodation for the recovery of persons who have suffered shipwreck. The spot upon which the town is built is nearly a dead flat, from which the sea appears to have gradually receded; but the soil, being a dry sandy beach, and the whole exposure completely open on every side, the climate is much more healthy than the lowness of the situation might give reason to expect. The town is neatly built, and consists chiefly of one spacious main street, from which numerous lanes run off on each side, as from the High Street of Edinburgh. Many of the houses have their gables turned to the street; but a number of more modern buildings are constructed in a different manner, and have a very handsome appearance. The principal public buildings are the *Town hall*, which has of late been greatly enlarged, and which makes a fine termination to the main street; the *Parish church*, which measures 98 feet by 65 over walls, a plain and well finished building, but awkwardly attached to an old and diminutive steeple; the *Episcopal chapel*, to the eastward of the town, neatly built and handsomely fitted up; the *Public schools*, in a safe and airy situation, and now almost entirely occupied by the English masters; the *Academy*, a spacious edifice, recently erected for the accommodation of the other teachers, and containing six large apartments, occupied by the master and usher of the Latin school, two masters for writing and arithmetic, a master for drawing, and a rector, whose department includes the different branches of mathematics, the elements of natural philosophy, and several of the modern languages; the *Lunatic asylum*, including also an infirmary and dispensary, founded in 1779, the first institution of the kind in Scotland, and which has been recently enlarged, and greatly improved in its whole appearance and arrangements; and the *Office of the British Linen Company's agents*, which forms one of the principal ornaments of the main street.

Montrose is a place of considerable commerce, and its shipping has, of late years, greatly increased. It is a port of the custom-house, and comprehends, within its bounds, the coast from the lights of Tay on the south, to Bervie-Brow, or the Todhead, on the north. In the month of March, 1820, the shipping belonging to Montrose amounted to 83 vessels, registered at 7046 tons, and navigated by 605 men. Five large vessels are employed in the whale fishery, but the greater part are engaged in the coasting and Baltic trade. The most important branch of the export trade is grain, which is said to exceed that of any other port in Scotland. Various branches of manufacturing industry are carried on in Montrose, particularly sail-cloth, sheeting and linen; the importance and progress of the last mentioned article of manufacture will appear from the following note of linen cloth stamped in the place.

	Yards.	Value. L. s. d.
From 1st Nov. 1815 to 1st Nov. 1816.	345,098¾	18,686 7 1¾
From . . 1816 to . . . 1817.	537,599½	27,405 6 10¼
From . . 1817 to . . . 1818.	513,410½	25,599 11 8
From . . 1818 to . . . 1819.	777,902	36,439 16 11

There is in the town an extensive tan-work and foundry; rope-walks, breweries, starch-works, soap and candle-works. There are excellent salmon-fishings in the river; most abundant supplies of fresh white fish from several fishing villages in the vicinity, and immense quantities of cod, particularly prepared by drying and salting, for distant markets. There are very extensive downs or links, between the town and the German Ocean, where the game of golf is generally played, and where races occasionally take place. There is a bank in Montrose, besides branches from the British Linen Company and the Dundee Union Bank. There are two newspapers, two printing offices, a theatre, lately erected, and an excellent public library, inststituted in 1785, which contains between five and six thousand volumes. Many genteel and wealthy families reside in the place. The inhabitants are distinguished for their intelligence and orderly habits. And, altogether, Montrose may be considered as one of the most interesting provincial towns of North Britain. The population is about 8000. (*q.*)

MONTSERRAT, one of the Leeward Caribbee Islands in the West Indies, was discovered in 1493 by Columbus, and was colonized in 1632 from the adventurers under Sir Thomas Warner. The island is of a circular form, and is about nine miles in diameter, containing about 30,000 acres of land, or nearly 47 square miles, of which about 6000 acres are laid out in sugar, 2000 in cotton, 2000 in provisions, 2000 in pasturage, the remaining two-thirds being mountainous. Cedars, cypresses, the iron-tree, and other woods and odoriferous shrubs, are produced on the island; and indigo was formerly raised in great quantities. From 1784 to 1788, the average crop was 2737 hhds. of sugar, of 1600 cwt.; 1107 puncheons of rum, and 275 bales of cotton. The following were the exports from Montserrat and Nevis in 1787, which were sent principally to Britain, the United States, the British colonies in America, and the West Indies:—

	cwt.	quart.	lbs.
Sugar, ...	111,284	0	21
Rum, ...	289,076	0	0 gallons.
Molasses	1,313	0	0 gallons.
Indigo, ...	140	0	0 lbs.
Cotton, ...	92,472	0	0 lbs.
Dyeing woods, valued at . .	352*l.*	7*s.*	6*d.*
Miscellaneous articles, valued at	1,363*l.*	3*s.*	5*d.*
Total value at the London market,	214,141*l.*	16*s.*	8*d.*

These articles were produced by the labour of about 1300 whites, and 10,000 negroes, which was the population of the island in 1791. In 1648 the white families were 1000, with a militia of 360 effective men.

In the year 1806, Montserrat imported the following articles of provision and lumber:—

	From Britain.	From United States.
Corn, . . .	6,230 bushels.	6,325 bushels
Bread, Flour, and Meal,	150 cwt.	19,555 cwt.
Beef and Pork, .	78 barrels.	416 barrels.
Dry Fish, ...		54 quint.
Pickled Fish, .	30 barrels.	632 barrels.
Butter, . .	19 firkins.	
Sheep and Hogs, ...		50 No.
Oak and Pine Boards . . .		395,908 feet.
Shingles, ...		597,000 No.
Staves, ...		117,600 No.

Montserrat is the most southern island under the governor general, and is 7 leagues SE. of Nevis, and 8 SW. of Antigua. West Long. 62° 13′ 25″ of NE. point, and North Lat. 16° 47′ 35″. See Edward's *History of the West Indies*, vol. i. and Gray's *Letters from Canada*.

MONTSERRAT, is the name of a mountain of Spain, in the province of Catalonia, celebrated for its hermitage, and as a place of resort for pilgrims. It is said to be about 24 miles in circumference, stretching from W. to E. along the right bank of the river Llobregat, and is equally remarkable for the composition, form, arrangement and position of its rocks. It consists of limestone, sand and pebbles, cemented together, and forming a kind of breccia. "The rich earth," says Laborde, "on part of these rocks being dissolved by the action of the rain water, has formed crevices full of trees and aromatic plants. This vegetation is the more extraordinary, as there is no spring on the mountain; the streamlets sometimes seen there appearing to proceed from reservoirs formed by rains in the crevices of the mountain, and running in the bed of porous stones, which lie across the middle of it." Hence the mountain seems to have been split into masses of the most grotesque shapes, in the form of caves, pillars, and rugged fragments, piled upon one another to the height of above 3000 feet above the level of the ocean. The view from the summit of Montserrat is extensive and grand. Corn, vines, and olives, cover the lower parts of the mountain. The situation of the highest peak of Montserrat is in East Long. 1° 46′ 7″, and North Lat. 41° 38′ 59″. See Laborde's *View of Spain*, vol. i. p. 125.

MONTUCLA, (Jean Etienne,) a French mathematician of considerable note, was born at Lyons, on the 5th of September, 1725. Being early distinguished for his love of knowledge, he was placed under the tuition of the Jesuits, from whom he gained the elements of an extensive acquaintance with science and classical literature. At the age of sixteen he quitted their seminary, for the purpose of studying law at Thoulouse, and, after the usual course of preparation, obtained a counsellorship in the Parliament of that city: but feeling little inclination for his employment, and meeting with little encouragement in the exercise of it, he renounced the bar in 1753, and removed to Paris, with the view of supporting himself by literary exertions. Soon after his arrival, being fortunately admitted to the society of d'Alembert and Diderot, their conversation gave a settled tendency to his pursuits, and he formed the project of that work, by which his name is so well known among men of science. At first, however, his efforts were limited to a lower department. He wrote in the *Gazette Françoise;* and translated several works, one of which was Lady Mary Wortley Montagu's report of the latest cases of inoculation at Constantinople. The utility of the practice at that time (1756,) about to be tried on a prince of the blood, was keenly discussed, and Montucla's translation appeared with advantage as an appendix to M. de la Condamine's memoir upon this question. Two years before, a subject more akin to the bent of his mind had furnished Montucla with scope for original investigation: it was the *Histoire des Recherches sur la Quadrature du Cercle*, received with an applause well calculated to animate the author in his great undertaking, the *Histoire des Mathématiques*.

Lord Bacon justly thought, that a rational account of the steps by which the mind had advanced to its actual proficiency, in the several departments of philosophy, might prove a work of great utility and entertainment. But though mathematical science is perhaps the only branch of human knowledge, which has attained the degree of accuracy and precision requisite for executing such an enterprize, the task of giving any thing like a regular narrative of the order and gradation, according to which the discoveries in that science had followed each other, seems to have been undertaken for the first time by M. de Montmort, the friend, and fellow-labourer of Bernoulli. M. de Montmort, however, did not live to complete his attempt; the materials which he had accumulated were entirely lost at his death, and Montucla had the undivided honour of supplying this desideratum. His work, in two volumes 4to, was published in 1758. The extensive acquaintance with the science, and the unwearied spirit of research which it displayed, were rewarded with universal applause; the defective arrangement, and the rather inelegant style, were forgotten in the general merits of the work, or excused, from the difficulty of treating so new and intricate a subject. In its first shape, the *Histoire des Mathématiques* extended only to the conclusion of the 17th century; but the author's diligence had not abated, and his promise of continuing the narrative to a later period was afterwards fulfilled.

In the meantime, however, his studies were impeded, though not suspended, by an appointment to the post of *Secretaire de l'Intendance* at Grenoble. His conduct in this office, which he held for three years, would seem to have given entire satisfaction, since, when M. Turgot was commissioned in 1764 to superintend the improvements which the government were endeavouring to introduce at Cayenne, Montucla was nominated to accompany him in the character of secretary, dignified also with the title of Astronomer Royal. Of Montucla's celestial observations we have no account, but the science of botany is indebted to him for the knowledge of several equinoctial plants brought home on his return, which happened in 1766. After this short absence, he became chief clerk to the overseers of the king's buildings. In the discharge of that easy duty, Montucla enjoyed a competence, and found leisure to prosecute his inquiries concerning his favourite subject. The stormy factions, which desolated France during the revolution, seem to have left him unharmed, till 1792, when his office was abolished by the republican government, and the historian of mathematics was left exposed in his old age to all the calamities of want. It is painful to relate, that the man, whose respectable character ought to have secured him esteem and patronage, even if his arduous labours in the cause of science had not benefited mankind, was unable to gain the necessaries of life, except by consigning those talents which had illustrated the highest achievements of our species, to the management of a lottery-office! It was not till within a few months of his death that a scanty pension of 100*l.* from the government raised him above the miseries of abject poverty. But, in the midst of these depressing circumstances, Montucla did not forget his promise to complete the history of mathematics. Forty years of application had greatly augmented his knowledge of the subject; the second edition of his work, begun in 1798, was enriched with many new details in the period before examined, and the relation might have been conducted with equal skill to the proposed termination, had not death put a stop to his exertions, on the 15th of December 1799. Happily his manuscripts were in such a state as to be capable of publication. The printing of the first part was continued without interruption; and M. de la Lande, in 1802, arranged the remaining papers into two additional volumes, which continue the history to the beginning of the 19th century. Montucla was a member of the Royal Academy of Sciences at Berlin, and of the French Institute, from its commencement. His manners are said to have been amiable, his disposition kindly and generous. The *Récréations Mathématiques et Physiques* of Ozanam, which he edited in 1778, is the only work connected with him that has been translated into English. (T. C.)

MOON. In the article ASTRONOMY, the reader will find the fullest information respecting this planet. The map of the moon, given in this work, and forming Plate CCCC. is engraven on a reduced scale from that which was drawn by Dr. Brewster, and published in his edition of *Ferguson's Astronomy*.

MOORE (DR. JOHN,) a noted miscellaneous writer, the son of Charles Moore, episcopal clergyman at Stirling, was born in the year 1730. Mrs. Moore, upon the death of her husband in 1735, having removed to Glasgow, where she possessed some property, John, her only surviving son, enjoyed the benefit of being educated in the Grammar school and College of that city. After obtaining a considerable acquaintance with classical literature, he was placed under the charge of Mr. Gordon, a practitioner in surgery; and at the same time attended the lectures of the medical professors in the university, among whom Dr. Cullen was already distinguished for his original ideas regarding the practice of physic.

The knowledge acquired from these teachers was not long in finding employment. By the kindness of the Duke of Argyle, Moore, in the 17th year of his age, was appointed mate to the military hospital established at Maestricht, during the war which Great Britain at that time carried on for the Empress Maria Theresa. He afterwards served in a similar capacity at Flushing; and next year he became assistant surgeon in the Coldstream guards, and passed the winter of 1748 under the command of General Braddock, afterwards so unhappily remarkable for his fate in North America.

The arrival of peace, which put a stop to Moore's advancement in the army, afforded him the opportunity of attending Dr. Hunter's course of Anatomy in London; and soon afterwards the Earl of Albemarle, our ambassador at the French court, to whom Moore had been introduced in Flanders, invited him to undertake the duties of Surgeon to his family at Paris. During the two years of his residence in that city, Moore diligently employed all the facilities which his situation afforded, to improve his medical knowledge; and so ardent was his desire of attaining this object, that he declined residing at the ambassador's house, in order to have more frequent opportunities of witnessing the practice at the hospitals, by living in the neighbourhood of those establishments. Constant application naturally increased his professional skill, and gave a favourable opinion of his assiduity; and Mr. Gordon was sufficiently impressed with the character and abilities of his former pupil, to propose admitting him to a share of his practice at Glasgow.

In partnership with this gentleman, and afterwards with Mr. Hamilton, professor of Anatomy, Moore enjoyed considerable success for a number of years. The University of Glasgow had honoured him with a degree; the cares and pleasures of a family were now added to his other engagements; and in the bosom of domestic comfort, his life seemed to give promise of being respectable and happy, but not distinguished by any thing superior to the lot of those around him; when, in 1769, an event occurred which imparted a new colour to his future pursuits. Among the patients who at this time came under his care, was James George, Duke of Hamilton; a young man possessed of talents and virtues, which were only prevented from doing honour to his exalted station, by the attack of a consumption that baffled all the arts of medicine, and cut him off in his fifteenth year. Dr. Moore's services, though ineffectual, were gratefully acknowledged by the family to whom they had been rendered. He wrote the epitaph, which records the fate and character of his patient, in Hamilton churchyard; and as the surviving brother of this nobleman was of a weakly constitution, his mother, for that reason, felt desirous that he should visit the continent in company with a person qualified at once to direct his observations, and watch over his health. Dr. Moore, in whom both these requisites were united, was prevailed on to accept the charge. He left Britain with his pupil in 1773, and spent five years in visiting the most remarkable countries of Europe.

The fruit of those travels, 'A View of Society and Manners in France, Switzerland, and Germany,' published at London in 1779, and followed, in 1781, by a similar account of Italy, procured the author some emolument, and a considerable literary reputation. These works were speedily translated into French, and read with applause by the people whom they professed to depict. They were read with equal applause in England, and are still deservedly admired for their spirited descriptions, their perpetual flow of lively, if not profound observation, and above all, for the vein of pungent, yet on the whole, good-natured humour, which lends a charm to their other merits.

It does not seem that Dr. Moore's efforts to obtain employment as a physician in the metropolis, whither his family had removed, soon after his return from abroad, were equally fortunate: and the reception of his 'Medical Sketches,' published in 1785, appears to have confirmed his predilection for the career of a man of letters. The success which the novel Zelucco met with, was not calculated to disappoint such hopes. Its strong delineations of character and passion, its scenes of pathos and pleasantry, redeemed the occasional harshness and exaggeration of this work, and gave to it a more lasting existence, than generally falls to the lot of similar productions.

The fame arising from these performances procured to Dr. Moore the advantages of a society fitted to appreciate his acquirements. He had corresponded with Dr. Smollett, and was prompt to encourage the genius of Robert Burns. His time seems chiefly to have been engaged by such intercourse, and by a limited exertion of his professional abilities, till, in 1792, the French revolution having awakened the attention of all Europe, Moore visited Paris in company with Lord Lauderdale, for the purpose of more narrowly inspecting a phenomenon so extraordinary and so vast. The 'Journal' of his residence in France, which he quitted immediately after the fatal 9th of September, was published on his return to England; and the author's ideas upon the object he had been contemplating, were given in a more mature shape under the title of 'Causes and Progress of the French Revolution,' three years afterwards. Though the temporary interest which caused these works to be eagerly sought after, at the time of their appearance, no longer exists, they still merit a perusal. The first, in particular, is noted for the fidelity and spirit with which it sketches some events that will long figure in the history of the world.

From politics Dr. Moore again turned his attention to novels. But his 'Edward' (1796,) and his 'Mordaunt' (1800,) added little to his literary character. Though they retain some traces of his early vigour, they both exhibit symptoms of exhaustion and decay. They were the last effort of his genius: he died at his house in Clifford-street, on the 20th Feb. 1802.

As an author, Dr. Moore was more distinguished by the range of his information, than by its accuracy or extent upon any particular subject; and his writings did not owe their celebrity to any great depth or even originality of thought. As a Novelist he shewed no extraordinary felicity in the department of invention; no great power of diversifying his characters, or ease in conducting his narrative. The main quality of his works is that particular species of Sardonic wit, with which they are indeed perhaps profusely tinctured, but which frequently confers a grace and poignancy on the general strain of good sense and judicious observation, that pervades the whole of them. (T. C.)

MOORE, (Sir John,) a son of Dr. Moore, the subject of our preceding article, was born at Glasgow, on the 13th of November, 1761. Being destined for the military profession, he was educated chiefly on the continent; and whilst his father was abroad with the Duke of Hamilton, the interest of that nobleman procured him admission to the service, in the capacity of ensign to the 51st regiment of foot. It was at Minorca, in 1776, that Moore first entered the army; a lieutenancy in the 82d regiment was the next step of his promotion, and he seems to have held this station without much distinction, or any censure, during the several campaigns of the American war, in which he served till the arrival of peace, when his regiment was reduced in 1783.

A seat in the Parliament, as member for Lanark and the adjoining burghs, obtained apparently by the influence of the patron above referred to, did not long interrupt his advancement. About the year 1788, the office of major in the 4th battalion of the 60th regiment of foot, was exchanged for a similar post in his original regiment, the 51st, and followed by the commission of lieutenant colonel, which he purchased in that corps two years afterwards. From Gibraltar, where his military duties had placed him, he was ordered to Corsica in 1794; and the esteem of General Charles Stuart, formed an epoch in his military life. The siege of Calvi was the scene of this distinction; and his first wound was received in storming tbe Mozzello fort.

When a disagreement with the Viceroy had produced the recal of General Stuart, Moore succeeded him in the character of Adjutant-General; but as the subject of dispute with the Viceroy still subsisted, the new commander remained not long in good terms with him. His return to England, in the year 1795, seems not to have proceeded from dissatisfaction on the part of government; and his appointment to the rank of Brigadier General in the West Indies, which followed immediately, opened a new and more conspicuous field to his military talents. At Barbadoes, in consequence of his appointment, he met Sir Ralph Abercrombie, commander of the expedition destined to act against St. Lucie; and in this hazardous service, of which an important department was assigned to General Moore, he acquitted himself with that steadiness and gallantry which excited the warm applause of his superior officer. The conqueror of St. Lucie, who had already designated General Moore as "the admiration of the whole army," committed to him the prosecution of his enterprise, together with the government of the Island; and this charge, undertaken with reluctance, and rendered full of danger and labour from the hostility of the natives, and the number of Maroon negroes, who constantly infested the country, was managed with a decision and activity that overcame every obstacle.

Two successive attacks of the yellow fever soon forced General Moore to leave the West Indies; but, in company with Sir Ralph Abercrombie, he was destined to earn still higher distinction. The first scene in which they again acted together, was the Irish rebellion; and during those unhappy contests, notwithstanding the disorganised state of the army, General Moore's conduct was such as to obtain universal approbation.

After Sir Ralph's expedition to Holland, (1799,) in which General Moore was severely wounded, a wider and more briliant theatre was soon afterwards presented for their united exertions in the expedition to Egypt. During this celebrated campaign, General Moore fully supported the reputation for bravery and coolness which his former services had acquired. An important charge in disembarking the troops was assigned to him; and the battalion which he led was among the foremost in the far-famed enterprise of storming the French batteries, erected on a neighbouring eminence of sand, to oppose their landing. His subsequent efforts ably seconded the commander's arrangements, and contributed materially to the happy issue of their undertaking. That victory, which was purchased with the life of Sir Ralph Abercrombie, disabled General Moore for a time from farther exertion; a dangerous wound in his leg confined him first on board one of the transports, and afterwards in the neighbourhood of Rosetta, till the conclusion of the expedition. His merits were rewarded, on his return to England, by the order of knighthood; and public opinion seemed to point him out as a fit person for conducting any military operation in which the country might require his services.

The period for verifying those ideas was not long in arriving. After a few years of repose, General Moore (1808) was called to take upon him the command of an armament which the British government had prepared in aid of the Spanish Patriots, now engaged in hostilities with Napoleon. It is not our business to relate the particulars of this expedition. It is enough to observe, that after an advance to Salamanca, in which he was chagrined by every species of disappointment, cramped by restrictions, perplexed by misinformation, and, after a fruitless attempt to penetrate into Portugal, General Moore commenced a retreat to the coast, conducted it successfully in the face of an enemy greatly superior, and by his masterly dispositions at Corunna, repelled the formidable attack, in which a cannon-ball deprived him of life,—though not till his last moments were consoled by intelligence that victory had secured a safe embarkation for his troops. He died with the equanimity which became him, on the 16th of January, 1809.

Succeeding achievements of a more extensive and important nature, have already eclipsed Sir John Moore's reputation. But the intrepidity and manly uprightness of his character, manifested at a time when the British army was far from being distinguished in these respects, are qualities more endearing and estimable than military fame. They extorted admiration even from his enemies; and the monument erected by the French officers over his grave at Corunna, attests the worth of both parties. (T. C.)

MORAL PHILOSOPHY.

Moral Philosophy is the science which treats of the motives and the rules of human actions; and of the ends to which they ought to be directed.

In contemplating the general history of animated nature, we make no hesitation in setting down the habits of an individual as characteristics of the species, on the grounds that creatures similarly constituted, possessed of the same organs, and impelled by the same instincts, must have the same dispositions and feelings. The human race presents a remarkable exception to this observation; and the varieties which it exhibits in external appearance are not half so numerous or striking, as the contrasts which we observe in moral conduct and feeling.

Were mankind placed in circumstances precisely similar; were they possessed of the same extent of mental powers, and the same degree of natural feeling,—we could scarcely conceive a diversity of sentiment or conduct to be possible. But when we consider the infinite variety which prevails in the external circumstances, and undoubtedly also in the mental powers of man, instead of wondering at the contrariety of views and feelings, we have greater reason to be surprised at their general harmony and agreement. The differences seem to be only accidental; and, even where they are most apparent, a principle of congruity may generally be discerned, which leads to the same end, though by the employment of different means; and brings the most anomalous appearances within the ordinary range of human feelings.

There must, then, be some strong leading principles in the constitution of man, or in the ordinary arrangements of Providence, to preserve order amidst such discordant materials, which, in many instances, seem directed not only against the comfort, but against the very existence of society.

——— Vix nunc obsistur illis
Quia lanient mundum.

According to some, this object is accomplished by the continual interference of Providence, to rectify the disorders which the passions of men have produced. We are not much inclined to object to this doctrine. We would receive it with this qualification, however, that a wise arrangement, continually upheld by the Being who first contrived it, is to be considered as a direct display of divine providence. But, admitting this, we contend, at the same time, that a provision is made, in the nature of things, (not from any necessity of nature, but by the will of the author of nature,) for maintaining the equilibrium of the moral world, and for restraining the vices, as well as influencing the feelings and the conduct of men.

It cannot be a random principle which produces such uniform results; nor can it be a very abstruse one, since its influence is universal, and is felt, with various degrees of force, in every stage of human society. But though the general complexion of human manners bespeaks the operation of a principle common to human nature, there is nothing with regard to which men are less agreed, than the name and nature of that principle which produces such extensive effects. Men differ both as to the object which constitutes the supreme good, or chief felicity of their nature, and also as to the means by which it is most likely to be secured. They do not sufficiently distinguish between the principles which impel to action, and the objects to which they look for gratification. They are both indiscriminately called motives; and, certainly, when any object acquires paramount importance in the imagination, it operates as a motive in regulating the whole conduct. It is, however, in all probability, only a confirmed prejudice, arising out of a perversion of the original impelling principle, which is merely a vague appetency of our nature, calling for gratification, but not directing us, with infallible certainty, to a specific object, nor to the mode and measure in which it ought to be enjoyed. There is another thing, therefore, to be attended to in moral discussions, besides our elementary feelings; for, after adopting the instincts, desires, and passions, implanted in our nature, as the elements of action, we must examine how far these principles have been legitimately exercised, and consider in what instances they have been carried too far, or have fallen short of what they might have fairly achieved.

In investigating the principles of moral conduct, then, the natural method is, to begin with the simplest elements of feeling: and then to proceed to the circumstances which occur in the constitution of our bodies, or in the powers of our minds, or in the order of external nature, to modify, limit, and restrain our appetites and feelings: and if this process is conducted judiciously, we shall probably find, that the Author of our nature has established immutable rules in the ordinations of his providence, to lead us to the high purposes for which we are destined.

If we shall succeed in establishing this point, it will prove incontrovertibly that there is nothing arbitrary or conventional in morals; but that they result necessarily from the powers and faculties which God has given to man, and from the circumstances in which he has placed him. Even the most exalted moral precepts, derived from the light of revelation, will be found not to controvert, but to confirm this position. It is a great mistake to suppose that Christianity unfolds moral precepts foreign to the nature of man, and not cognizable by his reason. It is addressed to him as a perverted being, not as one destitute of the materials of knowledge: it shows that he neglects the riches which are among his hands, and that he fails to deduce the inferences which are obviously presented in his own nature, in the constitution of the external world, and in the ordinary events of providence. It is doing Christianity great injustice, to suppose that its moral precepts are such as never did or could enter the mind of man without it. Grotius takes up a very different argument to prove the divine origin of the Christian religion; for he endeavours to show that it was so reasonable, and so admirably adapted to the nature and circumstances of man, that all its precepts might be recognized in the scattered maxims diffused among the human race; but in all cases deformed by impure admixtures, and perverted from their original purpose by the vices and passions of men. The grand object of Christianity was, to unfold a plan of mercy, which must otherwise have remained unknown: its peculiarity, as a moral system, consists in the powerful sanctions by which its simple and obvious precepts are enforced. Instead, then, of being jealous of those moral maxims adopted, and beautifully illustrated, by many heathen authors, every Christian should consider them as so many attestations to the existence of that immutable law on which God has laid the foundation of morals. To deny the existence of such a law, would be to destroy at once the moral responsibility of man, where the light of revelation is unknown; for "where there is no law there is no transgression,"—an assertion which the apostle makes, not to free the unenlightened heathen from responsibility, but to show their great guilt in neglecting the clear intimations written on their hearts, and pointed out by the general constitution and course of nature. But unless such intimations existed, no blame could attach; for who could be censured for invincible ignorance?

The law of moral action is in fact so irrevocably fixed, that even when we violate it unconsciously, we are corrected, and called back to the consideration of the circumstances which have affected our comfort. Thus temperance, one of the cardinal virtues, is forced on us by necessity; and whenever we go beyond the limits prescribed by the constitution of our nature, we are instantly punished, and taught to seek that just medium which may satisfy, but not satiate; and exhilarate, without subverting by excessive excitement.

But although it is quite evident that the Author of our existence has put into our hands the materials of knowledge, and directed us, by the constitution and circumstances of our nature, to the course of moral action which we should pursue; yet it is certain that we never could convert these materials to our advantage, without the aid of information superior to that afforded by the natural reason of man. All that we have hitherto said amounts merely to this, that God has most abundantly furnished the means of information, with regard to the leading duties of morality: and we must now farther admit, that the materials of prejudice and error are no less abundantly supplied by the tendency of our appetites and passions. It is this which renders human nature a strange medley of folly and of wisdom; of virtuous feelings and depraved affections; which weakens the convictions even of the most enlightened, and teaches them to desire an authoritative rule and sanction, for the regulation of their conduct.—In short, the principles of natural morality stand pretty nearly on the same footing with the principles of natural religion: for though the being and attributes of God may be inferred from all his works, yet we see that the natural reason of man never led him to just and accurate conceptions on the subject. In the same manner, though the rule of moral conduct may be traced in the order of nature, and in the constitution of our own minds, yet there can be no doubt that the light of revelation was necessary, to enable mankind to distinguish, with certainty, truth from error, and the illusions of the passions from the rule of right reason. For who could decide with absolute certainty amidst the endless varieties of human opinions; or expect to have the authority of an oracle in commanding the assent of mankind?

This difficulty was so powerfully felt by Socrates, that he deemed it necessary that an instructor should be sent from heaven with special authority to reveal and enforce the duty of man. Cicero did not go quite so far as this; but his words evince no less clearly the necessity of such a teacher. He says, that he was not one of those who maintained that there was no such thing as absolute truth; but that error was so mixed up with every truth, that it could not be accurately distinguished.* And to prove the truth of this observation, he adduces the discordant opinions of the principal philosophical sects respecting the nature of the gods. If we are more fortunate than those two illustrious heathens, and can proceed with greater confidence in our investigations, it is because we have been favoured with a revelation which was denied to them, and which has materially influenced the moral discussions even of those who reject its assistance.

In our researches we do not mean to set reason and revelation in opposition to each other, but to exhibit them as mutually co-operating to establish the same important results. It is the proper province of theology to enforce the sanctions of revealed religion: it is the business of our present department to analyse the principles of moral action, and to point out their foundation in the nature and circumstances of man.—It is not indeed possible, in any discussion on the subject, to separate morals wholly from theology. For as soon as men have acquired a belief in the existence of a God, their moral perceptions must be considerably influenced by the attributes which they assign to him. If he is supposed to be cruel, or vindictive, or lascivious, we may naturally expect to see the same qualities exemplified in the character of his votaries; for wherever men have admitted the existence of a God, they have also admitted that they were bound both to imitate and obey him.—It is absolutely necessary, then, in all moral discussion, to endeavour to ascertain how far the unaided powers of man can go in obtaining right conceptions of the divine nature and attributes; for if these could be properly ascertained, they would constitute a rule from which there could be no appeal.

This point will be soon settled, if we take facts for the foundation of our argument, and consider what has actually been done in the province of natural theology by the unassisted efforts of the human understanding. We have only to recollect the impure and absurd theology of the Romans, Greeks, and Egyptians; which some writers have chosen to denominate *elegant*, merely because its absurdities have been concealed under the splendour of poetical diction and imagery: or we have only to read Cicero's book on the *nature of the gods*, and if facts may be allowed to influence our reasoning, we will not hesitate to pronounce at once the incompetency of human reason to discover the attributes and perfections of the Supreme Being.

It may, perhaps, be thought unfair to decide on the capabilities of the human mind, from its aberrations and perversions; and we may be called upon to contemplate what it is naturally able to achieve. But here our speculations must be involved in great uncertainty. We find, indeed, the belief in a Supreme Being to be almost universal. In many instances, we discover very enlightened views respecting the unity of his nature, and some of his attributes; but in no one case can we pronounce with certainty how far these notions are the product of unassisted reason. We have stated elsewhere, (see Logic,) the very natural process by which the idea of God may be supposed to arise in the human mind; but it is impossible to demonstrate that it ever has arisen, in any one instance, in this manner. We are firmly persuaded that there is no such thing in the universe as a system of theism, the pure result of human reason; for it will not be difficult to show that all the religions which have ever been in the world are either *traditional* or *revealed*.

As far as we are acquainted with the religious systems which prevail throughout the immense continent of Asia, from China to the Red Sea, and from Cape Comorin to Siberia, we may discover the traces of a *traditional superstition*, but not of a system of *natural religion;* for its features are too fantastic to pass as the offspring of reason. In the same manner, we may perceive that the religions of Greece, of Rome, of Egypt, and of India, had a common origin, not in reason, but in tradition; for reason is not so uniform in its aberrations, as to run into exactly the same conceits and absurdities.

Where, then, shall we discover the pure religion of nature? Not among the sages of Greece and Rome: they evidently and avowedly borrowed from more ancient sources. Not among the philosophers and hierophants of Egypt: they, in all probability, borrowed from India. Nowhere, indeed, do we find among any of these nations any pretensions to this religion of nature: they altogether disavow this origin of their religious opinions; for they have, severally, their legislators and their sages, to whom they ascribe the origin of their laws and of their religion; and however much they may be disposed to reverence these founders of their polities, civil and sacred, they never ascribe to them the honour of discovering, by their own ingenuity, the laws and religious opinions which they promulgated. These they ascribe to the particular favour and illumination of the gods.

This opinion, if not strictly correct, may, perhaps, lead us to the truth; for were we to judge from appearances and partial facts, we would perhaps be led to conclude, that man, on his creation, was placed under a system of revelation, or was made perfectly acquainted with the great truths of religion, immediately depending on the being and attributes of God. This inference amounts to certainty, if we take the sacred Scriptures for our guide. On the supposition, then, (and it is surely a natural one,) that this primeval religion was taught by the first race of men to their families and descendants, and by this means diffused over the face of the earth, we might na-

* Non enim sumus ii, quibus nihil verum esse videatur; sed ii, qui omnibus veris falsa quædam adjuncta esse dicamus, tanta similitudine, ut in iis nulla insit certa judicandi et adsentiendi nota.—*De Nat. Deor.* lib. i. c. 5.

turally expect those diversified features of superstition, which meet us in our researches, and which betray few marks of their parentage as the offspring of reason, but are exactly what we might expect as the corrupted traditions of primeval revelation.

If, however, it should be maintained, that the due exercise of reason will necessarily lead us to some knowledge of God, we have no wish to dispute the assertion: we only affirm that we have no instance on record, in which it can be proved that men have come by their religion in this manner: all the religions with which we are acquainted, bear evident marks of a different origin: and before the competency of human reason, to discover the most obvious truths of religion, can be ascertained, it would be necessary to find a nation entirely destitute of every notion of religion; to watch its progress in knowledge, and carefully to observe the result of its experience. But, indeed, there is every probability that a nation, circumstanced as we have supposed, if unaffected by any external impulse, and unassisted by extraneous example, would remain for ever in the barbarism in which it was found. No nation, however, has been found in this state of absolute ignorance; by whatever means men have come by their knowledge, they have always been found to have some idea of a superior power; and, possessing this as the rudiments of religious knowledge, we might naturally have expected that they would have made progress in a science so interesting. This expectation will not be realized; for we discover none of that elasticity of mind, which prompts to ulterior improvement in religious knowledge: all the efforts of philanthropy have scarcely been able to shake the inveterate prejudices of error, or to preserve alive the seeds of knowledge, where they have been sown. If the knowledge of God and his attributes, then, be the result of human reason, the mind goes through a process on this subject, entirely different from that which it follows with regard to any other of its attainments. It advances uniformly and steadily in all those improvements which result from study or experience, and length of time never fails to give maturity and stability to the principles of knowledge. But, in religion, the process is reversed; and lapse of time invariably leads to degeneracy and corruption. The most ancient writings of the human race approach nearest to the truth on some of the fundamental principles of religion. Thus, we find the unity of the divine nature explicitly stated in some of the most ancient of the Braminical writings, whilst the doctrine is totally unknown among the modern Hindoos, who are, and have been from time immemorial, the grossest idolaters in the world.

Let it be remembered, that we are only stating the aberrations of human reason on the grand fundamental principles of religion and morals; and we do not positively affirm that the mind is absolutely incompetent to discover the important truth of the being of God; but facts authorize us to conclude that it never could turn this important truth to any profitable account, without ulterior assistance; for it is instantly disfigured by the prejudices arising from human passions, and thus becomes the means of perversion rather than of improvement; as men canonize their own vices by exalting them into attributes of their gods.

We conceive it, then, to be absolutely impossible to found a system of morals on the basis of natural religion, which, if cognizable by human reason, is nevertheless, in every instance, so grossly abused as to become a source of error rather than of knowledge. The bountiful author of our nature has delivered us from this perplexity, by giving us a revelation containing rules of duty, which our consciences must instantly approve, and which, on examination, are found to be perfectly consistent with the light of reason, with the interests of man, and with the ordinary arrangements of providence. These rules, however, are not, in general practice, deduced step by step from the elements into which they may be analysed: they resemble, in this respect, the rules deduced from science, or experience, which are delivered to practical artists, and which lead them as immediately to the attainment of their object, as if they thoroughly understood the principles on which the rules were founded. It is evident that some rule of this kind is absolutely necessary for regulating the moral conduct of men; for few have time or talents for ingenious or laborious investigations; and were man left to discover the rules by which his conduct is to be guided, the best of his life would be past before he had learned how to live. Revelation unfolds the rule at once, without explaining the principles on which it is founded, farther than by assuring us that it is the will of God, who always consults our happiness. To analyse these rules, however, which have been beneficently revealed for the regulation of our conduct, and to discover their coincidence with the most obvious principles presented to the senses and reason of man, is a luxury reserved for those whose talents and education enable them to trace the chain of proximate causes, till they can connect it with the supreme lawgiver.

It might reasonably be supposed that the will of God, and the order of nature, would tend mutually to illustrate and explain each other. This must necessarily happen, provided that which is communicated as the will of God be indeed from heaven; for the same God who arranged the order of nature, cannot, consistently with any notions which we entertain of his perfections, give a revelation which contradicts it.

"Nunquam aliud natura, aliud sapientia dixit."

This argument has been carried by Hume to an unwarrantable and unphilosophical extreme in the case of miracles, which are a suspension, or contravention, of the ordinary laws of nature. Were miracles contrary not only to the established laws of nature, but to the known power and perfections of God, it would be impossible to believe them. But when we see that they are not inconsistent with divine power, since he who gave matter its properties, can as easily alter them; when we see that they are obviously useful in promoting some beneficent end, which could not be accomplished without them; and when, in addition to all this, we have a positive proof in the existing state of nature, that a miracle *must* have been performed before things were as they are; (for if the calling of light out of darkness, of order out of confusion, of substance out of nonentity, be not a miracle, we do not know what is—or if any one should insist that there never was any creation, but that all things have always existed as we see them, that man holds a creed more marvellous than any miracle;) taking all these considerations together, there can be no objection to miracles in the nature of things, and their credibility, in every instance, must depend on the evidence by which they are attested.

The will of God, where it is known, must always be the rule of conduct. Let it but be fairly established that a precept has proceeded from heaven, and it would be needless to argue where it would be impious to resist. But there are a great many cases to which this determinate rule cannot be directly applied. Even the revealed law of God does not afford a direct rule for the moral conduct of man, in many instances where it is of essential consequence that he should decide with prudence. He is, therefore, under the necessity of employing his reasoning faculties in order to connect the case which puzzles him, with some general principle, or to trace its alliance with some recognised law.

At first view, it might appear desirable, that no doubt should ever exist on a moral question; and that we should be instantly enabled to decide with certainty in every case, where we are called to appear as moral agents. But this is not the way in which the author of our nature trains us to knowledge and to virtue. Our intellectual faculties are sharpened by the necessity imposed upon us of unravelling the studied involutions of nature. Some connecting principle is always presented to us as a clue to direct our steps, or some analogous fact occurs as an illustration: and before we reach the object which we have in view, we are generally raised above it; having travelled through a labyrinth of knowledge, whose hidden treasures we have been compelled to explore. By this means we perceive that the truth which, in the outset, we proposed as the ultimate object of our researches, is only a link in the chain of causes which connect matter with its creator. Something similar occurs in moral investigations. A doubtful point is cleared up by tracing its connection with others more fully established, or with acknowledged axioms in the constitution of our nature; and we are thus led to the temple of truth through a path beautifully diversified, which affords pleasure and instruction at every step, and beguiles the tediousness of the way by the many interesting objects which are successively presented to our view.

Thus, the same law, which, in physics, leads us to general principles from individual facts, might, by a careful process of moral generalization, conduct to results no less certain, could we disentangle our reason from our passions, and subject our feelings to our judgment. Ample materials are furnished to assist us in these researches: and as moral truths are infinitely more important than any physical results, the beneficent author of our being has afforded more numerous helps to conduct us to conclusions so essential to our happiness. Instinct, reason, judgment, conscience, point to the same goal; and though they are all sometimes so bewildered as to miss the right road, yet they possess in themselves a principle of rectification, which both points out their error, and incites to fresh attempts to discover truth, happiness, and duty.

Besides the intimations which spring up within our own breasts, and which are confirmed by the general habitudes of human nature, we may learn lessons of morality from the instincts of the lower animals; and the constancy, fidelity, gratitude, and parental affection, which, in many instances, they display in such an eminent degree, cannot fail to strengthen our moral perceptions. Many beautiful illustrations in the sacred Scriptures are founded on this idea; and we are frequently exhorted to draw moral and religious instructions from the instincts and habits of the lower animals. "*Go to the ant, thou sluggard, consider her ways, and be wise;*" we are here directed to an excellent example of industry and foresight. "*Consider the fowls of the air, for they sow not, neither do they reap, nor gather into barns, yet your heavenly father feedeth them; are not ye much better than they?*" These plain facts afford an excellent argument for trust in Divine providence.

Nor is this all: our moral feelings are, to a certain extent, regulated by the physical constitution of our bodies, and by the circumstances in which we are placed; and whenever we fall into extremes, either of deficiency or of excess, we find monitors within and around us, to stimulate our languid affections, or to repress our headlong desires.

Although all these intimations of duty, which are so profusely scattered around, would in themselves be insufficient to afford a universally applicable rule of duty; (because our prejudices disqualify us from drawing sound and accurate conclusions;) yet they are powerful auxiliaries in moral reasoning, and afford essential aid even where conviction is produced by other means. A moral precept, confirmed by miracles, may, nevertheless, be contrary to our limited views, or depraved affections: in that case, we are compelled, rather than inclined, to submit. But let it be shown that the precept in question is exactly conformable in spirit, design, and circumstances, to what we observe and approve in other cases, and then all opposition must appear unreasonable, and we must stand condemned by our own mouths, and our own consciences. In fact, it is not demonstration that we so much stand in need of in moral reasoning, as persuasion. The grand truths of morality are sufficiently palpable to command the conviction of the conscience and reason; but something more is necessary to give them a firm hold on our feelings. In subjects of pure science, where nothing but reason is concerned, nothing but reason requires to be satisfied; and a demonstration silences for ever all doubts and conjectures. But the case is wholly different in morals and religion: these sciences are intimately blended with our feelings: and when they inculcate disagreeable truths, or unwelcome precepts, our passions and prejudices will, most probably, be up in arms to resist the convictions of reason.

In all investigations, then, into subjects of morality and religion, it is not enough that our own reason be satisfied; the point to be enforced must be made familiar to our senses; must be reconciled to our prejudices, and shown to be consistent with those notions which we are compelled to admit as primary and incontrovertible facts. Hence, we find, in general, that illustrations in moral subjects are more effectual than reasoning; and familiar views, drawn from an induction of obvious facts, are more satisfactory than the most elaborate abstract speculations.

In another part of this work, (See Logic,) we have shown how much our intellectual perceptions are influenced by the order and course of nature; and that those mental features which appear most singular, are impressed on the mind by that invariable order, which the Almighty has established among his works. This regular order both facilitates the acquisition of knowledge, and, by its frequent occurrence, stamps it, in indelible characters, on the human mind. The same observation applies to our moral feelings. The law of God is, indeed, the ultimate rule; but that law is written, to a certain degree, on our own hearts, because the very instincts which he has given us compel us to observe it; and our experience soon teaches us, that we never can infringe, with impunity, those rules which are indicated by the constitution of nature. God has written his law, not only on our hearts, but on the face of nature; and his revealed law is only the enforcement and illustration of principles which were always in operation, and might always have been discovered, had not the sins of man enfeebled and obscured his reason*.

Next to the revealed law of God, then, we would be disposed to say, that nature is our surest guide; we do not mean merely the feelings of human nature, which are evidently under a corrupting influence, but the nature of things, that is, the arrangements of providence, and the constitution of the external world. These are the aids which the Almighty has given to direct us to the knowledge of his will, and to strengthen that revelation which our ignorance rendered necessary. We conceive that this representation is confirmed by Scripture. At the very time that God was giving a positive revelation to Israel, he appealed to their own interest, and told them that the law which he ordained was for their own good. Deut. vi. 24.

And farther, that he might not seem to impose strange and arbitrary precepts, having no foundation but in his own despotic will, he told them, that the law which they were commanded to observe was perfectly conformable to the intimations of their conscience and reason. *This commandment, which I command thee this day, is not hidden from thee, neither is it far off:—but the word is very nigh unto thee, in thy mouth, and in thy heart, that thou mayest do it.*

Our intellectual and moral faculties, though most closely allied, admit nevertheless of an obvious distinction. It is the province of the intellectual faculties to receive impressions, to perceive relations, to examine our attainments, and to see if they have been legitimately acquired: and if it shall be found that we have viewed things as they are actually presented in nature, and have combined them according to those analogies and relations which the author of nature has established, we have nearly exhausted the philosophy of the human mind. The moral faculties have a farther, and most important office to perform: for it is their province to decide how far the things which are presented to our senses, or suggested to our feelings, are conducive to the general happiness of our nature, and to what extent we may enjoy them consistently with our duty as moral agents. Those original impulses of our nature, or those desires and feelings of want which are born with us, put in motion the intellectual machinery of the human mind; they direct it to certain objects of gratification; and when these are obtained, it is a matter of feeling to decide on the degree of enjoyment which has been received. If, instead of enjoyment, the result has been pain, we are forced to conclude, that the object which has produced this effect, is not intended for gratification; or that we have not applied it aright for the purposes of enjoyment.

We are thus impelled to fresh pursuits, and when, at last, we discover that, which yields the desired enjoyment to ourselves, without impairing the happiness of others, and which is approved by our reason, whilst it gratifies our feelings, we conclude that we have found the right medium prescribed by the author of our existence. These experiments may go a considerable length in ascertaining the rule of moral conduct; for we are not left to grope at random; nature and conscience are always at hand to direct or to restrain us; and we are surrounded, from our very birth, by moral relations, which train and discipline our minds, involuntarily and unconsciously, to the habits and duties of moral agents.

But here we must observe, that those circumstances which constitute the rule of moral action do not, by any means, necessarily give us the idea of moral obligation. We can easily perceive, that we cannot exceed certain limits without destroying our own happiness; a regard to our own comfort, therefore, will compel us to respect those boundaries which nature has prescribed, as necessary to preserve us from the excesses which ruin our respectability or enjoyments. But there is no more virtue in this than there is in avoiding the fire which has burned us, or the food which has impaired our health, or the person who has injured or betrayed us. We are merely obeying a law which we dare not violate, from apprehension of the consequences; and which has the force of a statutory enactment, to secure the submission even of those who may dislike the injunction. We cannot conceive how it is possible that there should be any idea of moral obligation, without the idea of accountableness to that Being who created the universe; who implanted in our nature those faculties which enable us to act, and to judge; and who has established that order of nature which we are compelled to respect. Take away the conviction of this accountableness, and there is no distinction between virtue and vice; and nothing is left but a sordid calculation of the consequences which may affect our present comfort. A man's visible interest would then be his only rule, and there would be none of those high-toned principles, which make the *nil conscire sibi* the proudest distinction of human nature: the object would then be, to preserve a good name rather than a clear conscience; the most profligate would be sensible of no baseness; and the most abandoned wretch would lift his head erect, so long as he could conceal his turpitude from the world.

In order, then, to obtain a moral principle of sufficient efficacy, man must consider himself as amenable to the laws of the Supreme Governor; and he must seek to know his will by all the means by which he has been pleased to make it known to men: he ought gratefully to avail himself of the light of revelation, and he ought not to disregard those intimations which are presented in the order and course of nature; he ought to consider them as so many auxiliary hints to strengthen the obligations of virtue; and even as useful to ascertain many points of importance, which are not settled by a positive rule, but may easily be reduced to a general law.

Holding these views, we cannot subscribe to the opinions of Butler, and Mr. Stewart, (who is very much influenced by him,) that nothing farther is necessary to show the obligation of the law of morals than the bare recognition of its existence. "Your obligation to obey this law," says Butler, "is its being the law of your nature." But, according to the usual conceptions of men, wherever there is a law, there is a lawgiver; and it is

* Proinde sic statuimus nihilominus divina precepta esse ea, quæ a sensu communi et naturæ judicio mutuati docti homines gentiles literis mandarunt, quam quæ extant in ipsis saxeis Mosis tabulis. Neque ille ipse celestis pater pluris a nobis fieri eas leges voluit, quas in saxis scripsit, quam quas in ipsos animorum nostrorum sensus impresserit. *Melancthon.*

not the law itself, but the power and authority of the lawgiver, which enforce its obligations. Allowing, then, that the law of our nature were ever so clearly recognized, it could not be viewed as an object of moral approbation, were we persuaded that it was the result of fate, or of accident. It is only as proceeding from an intelligent cause, and from a being who has willed and planned our happiness, that we can admire and love the law under which we act; for it is then only that we consider it as an intimation of the will of a being who is the sovereign arbiter of our fate, and who will undoubtedly, some time or other, give full efficacy to the laws which he has established.

"Every being," says Mr. Stewart, "who is conscious of the distinction between right and wrong, carries about with him a law which he is bound to observe; notwithstanding he may be in total ignorance of a future state." This is the same idea as Butler's; and we apprehend it brings consequences after it which neither of these writers would have been very ready to admit; for, on their principles, it may be equally affirmed, that a person totally ignorant of the being of God, or one who denies his existence, may feel all the obligations of virtue; and that an atheist may be the most virtuous person in the world. This must be the natural consequence of making virtue the result of a moral sense; for such a faculty should convey its intimations to the mind as infalliably as perception; and the atheist and the believer should equally feel its power.

The common sense and experience of mankind revolt at such an idea; and, till modern times, neither moralists nor legislators have ever imagined that there is a moral sense in man of sufficient efficacy to regulate his conduct, independent of the belief of a God, and of a future state. The practice has always been to impress on the minds of men a conviction, that the moral precepts which they were required to obey were the laws of the gods, and that they must be accountable at their tribunal for the neglect of them. This appears to us to be not only good policy, but sound philosophy; and to lay the only sure foundation on which we can ultimately rest the feeling of moral obligation.

A man who has no idea of a God or of a future state, may, nevertheless, be trained to a certain course of conduct conformable to the general views of the society in which he lives. If he acts in opposition to these views, he will be blamed or punished; for he then breaks through the rules of the confederacy; and he may be expelled from the community, as we are told the rooks do with their pilfering companions, when they are detected in the act of carrying off the materials of their neighbours' nests. To avoid punishment or shame, then, is sufficient to induce conformity to established rules and customs; another motive will be furnished in the praise which attends every man who respects public opinion; and he who is forward in defending the rights of the community, will be courted and applauded for the protection which he affords. Here, then, is a standard of approbation and disapprobation, founded in public opinion, which is often iniquitous and absurd, when considered in reference to higher principles, or the rights and interests of other communities; and we have thus a moral condition, if it can be so called, of human nature, without any reference to a moral governor. We believe that many large communities exist in this state, fettered by inveterate prejudices, and referring to them with promptitude as the laws of their nature.

But there are many laws of our nature which are not moral laws at all. It is a law of our nature to eat when we are hungry; it is a moral law which says, *Thou shalt not steal.* In this view, the law of our nature is totally distinct from the law of moral obligation. The former arises from instinct or appetite, or from prejudice, to which custom has given the force of a law. The law of nature is limited by the moral law, which defines the boundaries of our enjoyments. This moral law is neither instinctive nor intuitive; it can only be discovered by reference to revelation, to experience, or to observation of the obvious designs of providence. It is true that moral laws are also laws of our nature, that is, they are framed by the author of our nature for our happiness and improvement; but they become obligatory on our conscience, only in consequence of our referring them to the will of a superior, to whom we owe allegiance, and who is entitled to it from his uniform kindness and benevolence, as well as from his sovereign power and authority.

The ideas of *right* and *wrong* are acquired at such an early period, and confirmed by such a course of constant discipline, that we are apt to consider them as instinctive feelings, or as original independent intimations of conscience; and the opinions which tend to modify or controvert this doctrine are generally viewed with some suspicion, as being conceived to have a tendency to shake the eternal foundation of moral virtue. In so far as our particular opinions are concerned, this alarm is entirely groundless; for we most zealously contend for the eternal unalterable distinction between right and wrong; but, we contend, that the mind does not possess in itself any particular power or faculty which decides, *suo jure*, on the moral fitness of actions; and that its decisions on this important point must be settled by showing the conformity, or non-conformity, of any action with the general order of nature, to which our feelings, faculties, and powers, are adapted. By this means, we perceive that the distinction between right and wrong is not fanciful, nor casual, but fixed and permanent, having its foundation in the ordinations of providence, which God has made us capable of observing, and which are presented to us every day, and every hour, that we may be trained to the functions of moral beings.

What use is there, then, for a moral sense, to perceive what is every moment of our lives pressed on our notice, and rendered familiar to our understanding by a thousand instances? Is it a moral sense which teaches parents the duty of loving their children? No, it is an instinctive feeling; it is exactly the same with that which regulates the lower animals, who might, with as good reason, urge their pretensions to a moral sense, on the ground of parental affection? Is it a moral sense which enforces the duty of conjugal fidelity, and shows the beauty of this virtue? No, this duty results from perceived necessity and expediency. Is there a moral sense which tells us that polygamy is improper? No, but we soon perceive it to be so from the burden and inconvenience, the jarring and discomfort which necessarily arise from a double or divided family. We should like to see how the impropriety of this practice could be evinced on the principle of a moral sense. On our principles there is no difficulty; for, besides the personal inconvenience which it produces, we can show that the order of nature is in favour of monogamy; the birds of the air, and the beasts of the field, separate into pairs, and during the season of their loves remain faithful to each other; and the same lesson is inculcated on the human species by the proportion between the sexes; an argument which the author of our religion did not disdain to employ, when he said, *he that made them at the beginning made them a male and a female.* Is it a moral sense which proclaims the virtue of patriotism? No; we are trained to it from our infancy, in consequence of those powerful associations which arise from common laws, and common religious feelings, and common protection, and common interest, all which cement the population into one body, and knit the soul of the community into one common feeling. Does any moral sense teach us our duty to God? No; our feelings often revolt from this duty, whilst our reason can point out a thousand arguments to enforce it.

Our readers will perceive that we have been arguing against a *moral sense*, only in the light in which it has been viewed by several eminent modern philosophers, such as Butler, Reid, Stewart, &c. as a distinct power of the mind, enabling it to perceive the moral beauty or turpitude of actions; and whilst we dismiss it, in this sense, as totally unnecessary, we have endeavoured to shew that there is a radical and essential distinction between right and wrong, fixed by an unalterable law, which we are compelled to recognise, because we cannot recede far from it without ruining our happiness.

We are not to seek, then, for the law of moral action solely in the mind itself; this would carry us back to the innate ideas of Descartes; the mind collects it partly from its own feelings and faculties, partly from the bodily capacities and functions, and partly from the order of nature, or the circumstances by which we are surrounded, which are ordered and disposed by the author of our nature, and influence materially our feelings, our opinions, and our actions. By comparing all these things together, we learn to distinguish between what is local or accidental; and what is fixed and permanent; and we perceive distinctly that the line of conduct resulting from the knowledge thus acquired, is not only consistent with the will of heaven, as intimated by the course of Providence, but is also perfectly consistent with our own happiness. It is only by this enlarged view of the subject, that we learn to correct the narrowness of private feeling, and to consider our own happiness as identified with the public good. An individual who looks not beyond himself, would be disposed to view many things that befal him as exceedingly wrong, and to regard them with the strongest disapprobation; but when he considers these things as happening by the fixed ordinations of Providence, and that, of course, they must be useful in their general tendency, though disastrous to him, he then views himself as a fellow-subject under the same moral government, and learns to approve whatever promotes the plans of the Supreme Legislator. He then learns that true self-love and social are the same; and he learns, moreover, that *to be virtuous*, and *to consult his own interest*, are, in fact, synonymous expressions. Partial views of expediency, or limited conceptions of God's moral government, or turbulent and ungovernable passions, may often make these expressions appear not only different, but opposite; but they are identified by the nature of things, and the appointments of heaven. And we are inclined to think with King, that the disagreement of authors respecting the criterion of virtue, is rather apparent than real; and that "*acting agreeably to nature or reason*, when rightly understood, would perfectly coincide with *the fitness of things*; the fitness of things, as far as these words have any meaning, with *truth*; truth, with *the common good*; and the common good with *the will of God*."

It follows, from what we have already advanced, that whatever tends to promote the best interests of man must be right, and conformable to the will of heaven; and that, in searching for a rule of moral conduct, we will always find it to coincide exactly with that which promotes the real happiness of man. Much misconception has arisen on this subject, from confounding the motives with the rules of action. Were there no sinful bias in human nature, and no tendency to excess in its original passions, the motives and the rule would always coincide: in that case, whatever man willed would be right, and his own inclinations would be an infallible rule of right conduct. But as it is evident that the passions often act with undue violence, and are directed to improper and illegitimate ends, the only rule that we can have for the management of them is, to consider the consequences which they produce, in their various bearings on our character, our present happiness, and our future hopes. If they contradict any intimation which we have received from the word of God, or the light of nature, we have reason to feel alarm: but if these are not contradicted, whilst our present happiness and respectability are promoted, we have the concurrence of every species of evidence to prove that the passions, or appetites, or desires, have been legitimately indulged, and directed to proper ends. We do not see any rule, then, by which we can judge of the proper degree in which any appetite or passion ought to be indulged, but by the expediency of the results to which it leads; and having learned by experience and extended knowledge what is most conducive to our own and the general good, we henceforth conclude that this is an object of rational pursuit; we studiously dismiss every motive that would divert us from the attainment of it; and the rule and the motive are again brought to coincide, as must have been the case in a state of perfect rectitude.

Mankind act at first without minutely calculating consequences, or having any regard to remote expediency; for they are trained to action either by authority, which they dare not disobey, or by instinctive feelings, which they are not inclined to resist. In this way, they often acquire habits which stick to them through life, and which they seldom examine, with a view to ascertain whether they be founded in truth and reason. When, however, they have been led to think, they soon begin to perceive that the habits which they have acquired, and the feelings which they have blindly obeyed, are referable to a general law, whose utility they are forced to recognise.

This is the general situation of mankind; they are, from their infancy, moulded by education, and trained to moral habits insensibly and involuntarily; but not accidentally; for every system of moral education has a foundation in nature, though it may be strangely distorted by circumstances, and scarcely reducible to the ordinary habitudes of moral action. When once their knowledge is extended, and they are able to examine the foundation on which their actions rest, they either find them, or endeavour to make them, consistent with that general plan which reason compels them to recognise, and to ascribe to an intelligent and benevolent ruler, whose laws they feel themselves bound to obey.

Those feelings, then, must be pronounced worthy of moral approbation, which give rise to actions which are salutary in their consequences, useful to ourselves, and beneficial to society; and calculated alike to promote our present happiness and our immortal hopes.

This is nearly, if not altogether, the doctrine of Expediency, as taught by Paley, which has been so generally condemned, and so little understood. It is the very principle, however, which seems to regulate all the proceedings of the Almighty; the tendency of the whole being to promote the general good; and could we detect any thing in the economy of Providence, decidedly malignant in its aspect and tendency, we should be forced to exclude benevolence from the list of the divine perfections. But as we pronounce the ways of God to be good, from perceiving that the result is beneficent, can we hesitate to pronounce our approval of human actions, when their tendency coincides with the plans of Providence, and when their end is to promote the general good? But there are some who seem as if they never could be satisfied, unless virtue and interest are set at variance, and happiness and duty rendered inconsistent. They seem to be influenced by the same principle as the Religionists, who seek for merit by austerities abhorrent to nature; or as the worthy Father, who wished he had been commanded to believe what was impossible, that he might have had it in his power to give a satisfactory evidence of his faith. Who can hesitate to explode such notions as hurtful follies? And we aver, that they do not think more soundly, who imagine that virtue must be inconsistent with their present interest and happiness. In prosecuting a course of virtuous conduct, we may be compelled to forego some temporal advantages, which may fall to the lot of persons whose consciences are less scrupulous than ours; but this involves no forfeiture even of present happiness, since we have more satisfaction in the approbation of our consciences, or in the hopes of future reward, than we could have enjoyed from the gratifications which we voluntarily renounce, after a due calculation of consequences.

If, therefore, by *what is expedient*, we understand not merely that which promotes our present interest, and private gratification, but that which is most conducive to the general happiness of ourselves and others, for time and for eternity, we may certainly consider this kind of expediency as a test of the virtue of human actions, unless it can be proved that God has given some other rule inconsistent with these principles. But this is impossible; the Author of our nature is not such an unreasonable task-master, as to command the performance of duties from which we can derive neither profit nor pleasure. His precepts are sanctioned not only by the paramount authority by which they are enjoined, but also by their own reasonableness; by their adaptation to our circumstances; and by their tendency to promote our true happiness. We have thus every conceivable inducement to virtuous conduct, since it is found to be not only conformable to the will of heaven, and to the law of conscience and of reason, but also perfectly consistent with the best interests of man. To suppose that what is expedient, in the extended sense in which we have understood the term, can by any possibility be wrong, would be to subvert at once all our ideas of the moral government of God, which can be understood only by the perceived tendency of the plans of Providence to promote some good and beneficent end. We may surely, then, judge of the moral character of human actions by their tendency to promote the best interests of man; and we may find the origin of moral approbation, by applying to the actions of men the same *criteria* by which we judge of the wisdom and goodness of God.

It cannot be denied, that the doctrine of *expediency* may be grossly abused; it is the abuse of it that gives rise to all the aberrations of human conduct; for, whenever any man deviates from the straight path of rectitude, he proposes to himself some present or ultimate advantage; but his views are limited to selfish and temporal gratifications; and he forgets the duties which he owes to society, and to himself as the heir of immortal hopes. But the doctrine is not answerable for these abuses and perversions of it; these must be charged to the account of the headlong passions of men, which, for the sake of a little present gratification, make them overlook their duty as rational, social, and immortal beings. Nor can it be denied that we are exposed to numberless temptations, which induce us to take very short-sighted views of expediency, and to consult our own comfort at the expense of the general good; but reason and conscience are given us to combat these temptations, and to raise us above narrow and contracted feelings, to the rank and dignity of moral beings. So powerfully do these principles operate, and so distinctly do they proclaim that man is formed to take an interest in the common welfare of his species, that there is nothing of which he is so much ashamed as to be convicted of selfishness and want of feeling for the distresses of others.

It is observed by Dr. Smith, that the loss of a finger will cause infinitely more uneasiness to an individual, than to hear of the loss of the whole empire of China; yet, he observes, that no man would hesitate to make such a sacrifice to save so many millions from destruction. The observation holds true with regard to cultivated man, whose mind has been trained to observe the various dependencies in human society, and to see the principle of philanthropy, generated at first in the narrow family circle, gradually diffusing itself through the whole family of mankind.

> Friend, parent, neighbour, first it will embrace,
> His country next, and next all human race.

But an uninformed savage who has not learned to read the will of Heaven, in the ordinations of Providence, and to perceive that his own happiness will be promoted by expanded feelings, would not give one joint of one finger to save half the world from ruin; and this, surely, is as clear a proof as can be desired, that philanthrophy is not the result of any particular moral sense or natural feeling, but the consequence of enlightened reason, of improved principle, and of matured wisdom.

Thus, from limited views of expediency, very great errors may arise; for a man is extremely apt to consider every thing as inexpedient, which thwarts his views, or obstructs his favourite pursuits. To this contracted principle may be ascribed all the ravings of party spirit, and the aggravated colouring in which every partisan represents his opponents. These are exhibitions of human character, which sound wisdom will teach us rather to pity than condemn; for we can easily perceive that no man can have any great liking for qualities which eclipse his own fame, or prevent his own advancement. When placed beyond the possibility of interfering with our interests, we can praise and admire them; when death removes the grounds of emulation, we can shed a tear over the ashes of a rival, whom, when living, we feared and detested. *Extinctus amabitur idem.* Though this is not exactly what it should be, and though it presents not a very flattering view of human nature, yet it must almost necessarily take place in a complicated state of society, where so many are contending for the same prize, and eagerly desiring the same enjoyment. In such a state, one man's interest must often stand in the way of another's, and the prosperity of one must often be at the expense of another's comfort. Hence arise envy, jealousy, and detraction, qualities extremely odious, but naturally springing out of limited views of expediency and interest, and not easily corrected, we fear, by considerations merely moral; for, though reason may easily show their impropriety, it cannot so easily subvert their influence in the human heart. But let it be remembered that the evident design of the Supreme Lawgiver is, to promote the general good of the human species; and that when this object is accomplished, individuals are not to consider their partial inconveniences as any exception to the divine goodness. If they suffer in one respect, they may be improved in another; the loss of worldly wealth may be the acquisition of substantial wisdom; and the trials to which they are exposed may be the means of calling forth their mental energies, and of exhibiting a display of virtues and endowments to meliorate and improve the world.

Let it then be kept in view, that man is accountable for his actions at a higher tribunal than that which is constituted either by conscience or public opinion, (and without this consideration there can be no moral responsibility,) let this be kept in view, and there will be little danger of abusing the doctrine of expediency, or of making it subservient to low and selfish gratifications. Every individual will then consider himself as bound to promote that general happiness which he sees so carefully consulted and provided for by the Parent of the Universe; even though, in doing so, he should be compelled to forego some private advantage of his own. But it is not generally necessary to make such a sacrifice; for public prosperity cannot possibly arise out of general individual misfortunes; and those measures which are best for the whole, will generally be found best for every individual of which the aggregate of society is composed.

The same observations hold true with regard to the general intercourse of nations with each other. Justice, in the long run, will always be found to be their best policy; though the violation of this principle may often promise many great and decided temporary advantages. It is not long since we heard it proclaimed, in the face of the whole world, that it was expedient for the safety of the French empire that Spain should be annexed to its already overgrown possessions. The same argument has always been employed, wherever a powerful nation wished to invade the rights of its feebler neighbours; and in all cases the general result has been the same; either an enthusiastic spirit of resistance has been produced, which defeated the design of the aggressors; or passive acquiescence begets in them a supineness and effeminacy, which soon render them fit and easy objects of vengeance.

When this merited retribution occurs, it is very generally reckoned an interposition of Providence to punish the guilty. We conceive this opinion to be erroneous. No interposition is necessary in such cases; they fall under the general laws of an overruling Providence; and by the operation of natural principles and feelings, they bring their own corrective along with them. We see, no doubt, the hand of Providence, whenever the foolish reap the fruits of their folly; or when the presumptuous fall by their own pride, or the profligate by their own excesses. But there is nothing unusual here, to deserve the name of an interposition; all these instances are embraced by the ordinary principles which regulate the dispensations of Providence, and which have fixed, with unerring certainty, the consequences of human conduct. Were it possible to preserve moderation, when in possession of absolute power; or prudence, when crowned with continued success; or energy, when wallowing in luxury; or abstinence, when unrestrained by principle; in such circumstances, it might be necessary for the Supreme Ruler to depart from the usual principles of his government, and to interpose in an extraordinary manner to punish the guilty, or to break the rod of the oppressor. But the case is amply provided for by the ordinary arrangements of Providence; and the circumstances which we have stated never fail to produce such consequences as tend to bring mankind back to the sound principles established by the law of God, and illustrated in his moral government of the world.

We trust, then, that it will appear, from what has been said, that whatever is right, and just, and proper, is also most expedient, both for individuals and for nations; for the ways of Providence, which evidently sanction these principles, never can be supposed to direct mankind to a course of conduct which will be ultimately unprofitable. This proposition, indeed, will be assented to by the most scrupulous moralists; and yet is it not perfectly convertible, and may we not say, with equal propriety, that whatever is ultimately and essentially expedient for men, must be right, and agreeable to the will of Heaven? Would it not involve a monstrous absurdity to say, "this is, *in every respect*, most expedient for you, but it is wrong, you must avoid it?" For what can influence the conduct of any human being, but a regard to his best interests? It is true, indeed, that what is expedient for one particular purpose, may be wrong; but this is only because it is inexpedient upon the whole. This was the case with the plan of Themistocles for burning the combined fleets of Greece, that the Athenians might be undisputed masters of the sea. He had stated publicly that he had devised a measure of the utmost consequence for increasing the power of Athens, but that it could not be divulged without defeating the execution of it. Aristides was ordered to communicate with him; on hearing the scheme, he instantly repaired to the assembly of the people; and without informing them what the measure was, declared, that nothing could more effectually promote the superiority of the Athenians, but that *nothing could be more unjust.* The feelings of the people, on this occasion, acted with instinctive promptitude; and, relying on the opinion of one whose name was identified with that of justice, they ordered the measure to be rejected without farther examination. Had they acted differently, this illustrious Athenian could easily have shown them, that mutual good faith was essential to the peace and the intercourse of nations; and that, without this, they must be perpetually engaged in wars of extermination against each other.

After all, however, we are more anxious to rescue the doctrine of *expediency* from the undeserved obloquy to which it has been exposed, than to found on it our system of morals. We consider it, particularly as it is explained in the writings of Paley, as a beautiful illustration of the wisdom and benevolence of the divine government, in having made the duty of man, in every respect, consistent with his best interests. But we conceive the principles of morals to rest on a still simpler basis, and to be pointed out by circumstances and facts in the constitution of our nature, long before we have any idea of their general expediency or unfitness. It is only after the mind is enlightened by varied knowledge, and the principles improved by patient culture, that we discover our real interests, and discern the wisdom and goodness of the divine government. Till we reach this point, we are pretty much in the situation of children whose humours are crossed by a parent's authority, and whose views of expediency are very different from his. They find, however, at last, that he understood their interests much better than they did themselves, and that obedience was both their interest and their duty. There cannot be a doubt, that we will ultimately make the same discovery with regard to the law of God: in the meantime, it is our duty to listen to the plain intimations by which his law is enforced; in the confidence, that in the end we will find the result to be both profitable and expedient.

If, then, our duty as moral agents be perfectly coincident with our best interests, we may safely assume expediency, in the enlarged sense in which we have considered it, as a sure *criterion* of virtue: for it is impossible but that which is most conducive to the temporal and eternal interests of man, must also be agreeable to the will of God, who, in all the arrangements of his providence, has obviously consulted our happiness.

If we admit that this is a fair *criterion*, we may perhaps be able to throw some light on the much agitated question, "To what principle in our nature we are to ascribe the feeling of moral approbation." For the question will then be reduced to this, What is the principle which enables us to decide respecting our best interests? And this question will be answered by considering what principle, or principles, are employed in comparing different actions, in anticipating consequences, in contrasting the effects of different gratifications, and in taking into view the general interests of man, as a social, rational and accountable being. Lest we should err in assigning to one principle what, in fact, we consider to be the results of several, we say, in general, that these operations are to be ascribed to the intellectual part of our nature: for we do not pretend to be acquainted with any principle but reason, which can show us the obligation to obey any law. Where visible authority is interposed, fear would compel obedience, even when the law is unreasonable: yet even here we cannot exclude the province of reason, which compares the different results of obedience and disobedience, and compels us to adopt the course most likely to ensure the least injury, or the highest satisfaction.

Conscience is generally supposed to be the chief agent in these decisions: and its power is indeed great; it acts with a force which is thought inconsistent with the nature of a secondary or factitious principle, and is appealed to as a sovereign arbiter in all discussions about right and wrong. It may always be safely trusted, when enlightened by knowledge and guided by reason: but without their assistance it is a dangerous, and often a destructive adviser; clearly evincing that it has no independent jurisdiction, and is possessed of no infallible certainty of decision. It is merely a mental habit, arising out of the circumstances of our nature, and strengthened by the most powerful associations, and the most interesting recollections: and is disciplined by constant use, till it acts with a rapidity and force which makes us forget every thing but the emotions which overwhelm us.

Suppose we should wish to enforce any one of the moral virtues, we can derive arguments both from the positive command of the Supreme law-giver, and also from many accessary circumstances which recommend present obedience, independent of more remote views of advantage. Let us see, for example, how we would recommend the virtue of *patience*, from considerations of a moral nature. In the first place, we feel that impatience renders us unhappy: this is a hint from our own nature, to teach us to repress our headlong passions, and to wait patiently for the desired consummation. In the next place, we see that impatience does not promote, but rather retard, the accomplishment of our wishes: here reason lends its suggestions in aid of our feelings, to strengthen the great moral lesson of patient endurance. But this is not all; the same lesson is enforced by the whole order of nature, and we are actually trained to it by the usual economy of providence. No man expects to reap on the same day in which he sows; no man expects all the time to be annihilated which lies between him and enjoyment: he is compelled to wait; and he cannot but see that it is best to do it patiently. We perceive that a certain portion of time, and a certain quantity of labour, are necessary for the production of certain effects, and that cheerful application is the best antidote against the irksomeness of labour, and the tedium of hope deferred. We see also that time is necessary for the evolution of the plant, and for its advancement to strength and beauty; and that we should completely blast our hopes, did we not patiently wait for the process and period of fructification. How beneficent, then, is our law-giver, who presents so many inducements to observe the precepts which he has enjoined, and who in fact makes the system of nature, and the arrangements of his providence, monitors to point the way to happiness and duty. By what arguments do we enforce temperance? Does any moral sense tell us how much we should eat and drink? No: but a rule no less certain is given us by the author of our nature: for we feel excess to be hurtful to our health, or we feel that it impairs our faculties, and gives undue strength to our passions; or we perceive that it will ruin our fortune, and thus ultimately destroy all our means of enjoyment. Any one of these reasons is sufficient to enforce temperance, and to show us that it is a virtue sanctioned by the wisdom of the Supreme Law-giver. Nor are we without arguments for this virtue drawn from the constitution of nature: for the earth produces enough for the temperate subsistence of its present inhabitants; but were we to double the consumption, one half must be starved, or the whole be inadequately fed.

All that we are anxious to establish at present is, that we are trained, to a certain extent, in the practice of morals by the very constitution of our nature, and that of the external world, before reason shows the expediency of a moral rule; and that a foundation is laid for the ideas of moral approbation or disapprobation, in the simple feelings of liking or aversion, which have been produced in our minds by conformity or nonconformity to the laws imposed on us by the author of our nature; which laws, in the first instance, we blindly obey, or heedlessly violate, till experience extends our knowledge, and shows the immoveable basis on which God has established the practice of virtue.

We are far from wishing to fritter down the moral feelings, and reduce them to mere operations of intellect: we are anxious, on the contrary, to preserve entire the enthusiastic love of the *pulchrum et honestum;* we wish to see it so firmly established in the heart, that it may act with intuitive quickness, and instinctive accuracy: and God has taken care that it shall do so, unless voluntarily and obstinately resisted: for we are trained to it every day; and the mind is as little sensible of any effort in distinguishing between the ordinary principles of right and wrong, as when it distinguishes by the ear the notes of a well known tune. Thus *habit* acts as the auxiliary of reason, and supplies the place of those instinctive principles which some contend for as necessary to produce the idea of moral approbation. This habit is neither the result of reason nor of accident; it arises out of the constitution of our nature, and the circumstances in which we are placed: and the office of reason is, to ascertain whether it has been legitimately formed, or has grown out of misconceptions of the human mind, and erroneous views of the nature of things. Did not our passions exercise an undue influence, and distort, as it were, the arrangements of providence, our habits would all be regular, and would be formed according to the law of nature, which is the law of God. But since there are so many things to mislead us, reason must exercise an impartial scrutiny, and endeavour to distinguish between those associations which are natural and those which are spurious; and between those habits which are accidental, and those which are founded on the immutable order of things.

To favour the opinion that a moral sense is necessary to give the idea of moral approbation, it has been alleged that the reasoning faculties cannot give us any idea either of the beautiful or of the good.* To be sure, reason does not produce the idea of the sublime or beautiful, but it enables us to analyse the principles on which it depends: and, in the same manner, goodness and moral beauty are not the creatures of our reason: it only recognises them as established by the law of heaven, as agreeable to the nature and circumstances of man, and as founded on habits which these circumstances necessarily produce.

But the fancy of some moralists is, that after reason has shown a measure to be consistent with the general good, and to harmonize with the general system, a particular sense is farther required to give the perception of moral beauty. This is similar to the whim which we have endeavoured to explode from intellectual philosophy; (See Conception and Logic,) viz. that after the reason, or whatever power it may be called, has collected the parts of an idea, or conception, into one whole, yet still a distinct faculty is required to act as gentleman usher, and introduce this stranger to the presence of the mind. We have shown that certain objects presented to the senses, are found at once to be agreeable or disagreeable. Two well proportioned pillars please the eye—two distorted or irregular ones offend it—harmonious sounds are agreeable to the ear, discortant ones are displeasing. But it often happens that the objects of perception are presented to us in such a complicated form, that we can, at first, discover neither beauty, nor regularity, nor harmony: by a process of reasoning, and patient investigation, however, we discover at last beautiful arrangement, and mutual subserviency, and adaptation of parts. The mind is then enabled to take in the whole at one glance, in consequence of the connection which reason has established among the parts; and can pronounce on the beauty or deformity of the *tout ensemble* with as much readiness as on simple proportion, when presented to the eye.

The same thing, we believe, takes place in our judgments respecting the merit or demerit of actions. We cannot but perceive, for instance, that cruelty is wrong; we dislike it when practised on ourselves, on our children, on our relations, or our friends: and, with these feelings, it never can be an object of moral approbation in any circumstances; for we soon acquire a general abstract dislike of any quality that is particularly offensive to us. In consequence of this, our judgments are often infected by prejudices which have arisen out of our own particular circumstances, and which give an undue bias to our opinions on general questions in morals. This, however, is only the abuse of that principle which leads us to decide, with almost intuitive readiness, on the merit or demerit of actions; and which has its foundation in the liking or aversion which we feel, when we ourselves are the objects of these actions. But perhaps the character of actions is not, at first sight, very apparent; we have, perhaps, complicated motives to examine, and a variety of circumstances to consider, before we can form a just estimate of the action subjected to investigation. We discover at last, however, we shall suppose, that cruelty or injustice lie at the root of the whole, and that every part may be resolved into these principles: in these circumstances, our earliest and most powerful associations lead us to pronounce a decided disapprobation of those qualities which we have been trained to dislike, which we hate when exercised towards ourselves, and which we soon learn to hate with abstracted unmixed dislike, in whatever circumstances they may appear.

Is not this the origin of that sympathy which forms such a remarkable feature in human conduct, and whose influence on our moral perceptions Dr. Smith has so beautifully illustrated? Taking sympathy in its most ordinary sense, as a feeling extended towards those who endure suffering, it obviously arises out of our own private feelings. Suppose the suffering to arise from cruelty or injustice, is not our sympathy for the sufferer excited, primarily, by our antipathy to the offence by which he suffers? There is an ingenerated abhorrence of the crime, and this elicits our affections and exertions in behalf of the sufferer. We believe this to be the real origin of our sympathy, in the sense in which we have at present understood the word; and we think it would not be difficult to show that it has a cognate origin, in whatever acceptation the word can be used. It is not, then, as Mr. Stewart alleges, a

* Phil. of Rhet. vol. i.

principle superadded to our moral constitution, as an auxiliary to the sense of duty; sympathy is a name invented to describe that particular effect which the sense of our own injuries or sufferings produces on our feelings, when we contemplate the injuries or sufferings of others; in which case our hatred of the injury makes us espouse the cause of the sufferer, and teaches us to adopt him as our ally in repelling the evils which beset humanity. We are perfectly sure of his concurrence, and rejoice to have found a person animated by our own views and feelings, and bound to us by a powerful common tie.

We are aware that sympathy is generally considered as a mysterious original power, which instinctively prompts the heart to feel for the miserable. This notion is disproved by the fact, that those who suffer least, have always the least sympathy; and were there any wholly exempted from suffering, we have reason to conclude that they would be monsters of inhumanity; unless they were trained to a kind of artificial benevolence, and thus taught to relieve sufferings, which they neither can sympathize with, nor comprehend. They, on the other hand, who have suffered most, have always most tenderness of heart, and feel the most anxious desire to relieve the afflicted.

Haud ignara mali miseris succurrere disco.

We hold, then, that all those things which are morally wrong, are either offensive to our feelings, or injurious to our interests. This is a safeguard to our virtue, provided by the wisdom of Heaven; and the very dislike of cruelty or injustice, is tantamount to moral disapprobation: for though, in many cases, there may be dislike, without moral disapprobation, yet this is only when moral agents are not concerned. A voluntary offence must always be viewed with marked disapprobation, as being an offence against the comfort and security of human nature, and against the general laws which God has appointed to regulate our feelings.

It is sometimes, indeed, extremely difficult to convince men that certain species of moral evil are hurtful to their interests; because perverted feelings counteract the influence of conscience and reason, and keep the mind in a state of torturing suspense between inclination and duty. These are moral *Idola*, which prevent the mind from recognising the obligations of virtue, in the same manner as the *Idola tribus*, &c. prevent it from discerning the obvious conclusions of right reason. But let the passions be lulled asleep, and let the injurious tendency of any practice to which we are addicted, be then demonstrated, and it will instantly be viewed with moral disapprobation, or rather with compunction, because we feel that it is a voluntary injury which we have inflicted on ourselves; and self-condemnation aggravates the unpleasant feelings which always accompany moral disapprobation. There are fewer obstacles to the exercise of a sound judgment in estimating the conduct of others: we disapprove, with instinctive readiness, of what is vicious, and commend, with equal promptitude, what is salutary and useful; not from any selfish views of benefit or injury, but because we have actually acquired an abstract love or dislike of certain qualities which have affected us; and that not accidently, but by the constitution of our nature, and the arrangements of Providence.

But perhaps it may be thought that greater uniformity in morals might be expected, if the principles which lie at the foundation of them are thus general, and fixed immutably in the constitution of things. In answer to this, we may observe, that though there are numberless circumstances which diversify the aspect of moral conduct, yet we are acquainted with no instances in which the ordinary principles of morals are reversed. We know of no nation in which a mother does not love her own child, or in which a son does not, in some way or other, honour his parent. We hear indeed of some tribes in which it is customary for children to put their aged parents to death. Supposing the fact to be fully ascertained, it would not militate against our assumption of *filial duty* as a general law of our nature. We may easily conceive that this unnatural practice arises from a mistaken sense of duty, and that the son reckons it an act of piety to terminate or prevent the sufferings of his aged parent.—We are told that, in Sparta, theft was reckoned a virtue: No such thing; but dexterity and adroitness were reckoned useful qualifications, as being akin to the stratagems of war, to which the whole policy of the state was made subservient. Theft was punished there, as it is in every other place, where a distinction of property exists; but he who stole, not from necessity or inclination, but to sharpen his powers of stratagem and cunning, was commended, as these qualities were deemed useful to the state.—In many nations, the sexual intercourse is extremely loose; yet we know of none in which the principle of appropriation does not obtain, and in which the relations of husband and wife are not recognized.

If we consider the worship of God as a moral duty, in which light it is undoubtedly to be viewed, we shall see the most immense diversity of absurd rites, and monstrous objects of superstition; yet, amid all these aberrations of the human understanding, the leading principle of religious worship is recognised, and the duty of man to adore a supreme power is acknowledged.—In short, amid all the diversity of human conduct, we can always trace some leading connecting principle, though infinitely varied, according to the circumstances of society, in regard to knowledge, education, and refinement. In some instances this principle is faintly developed, in others grossly perverted; but in all exhibiting features of affinity, which compel us to recognise its common origin, and to see that it has an immutable foundation in the arrangements of Heaven.

The history of the various nations which have flourished on the face of the earth, is chiefly interesting from observing the development of the same moral principle, from the first simple elements on which it is founded, till it is carried to the highest improvement and most extensive application of which it is susceptible. We are often struck with the singularity of manners and customs which we observe in different states, but our wonder vanishes on being made acquainted with their circumstances, prejudices, and habits. That which at first sight appeared singular or anomalous, is discovered to be natural, in the imperfect state of improvement which they have reached. It resembles the feelings of a child, which, though springing out of human nature, and laying the foundation of the attainments of manhood, yet appear removed at an infinite distance from the disciplined feelings of maturer years. Thus we see certain important principles very imperfectly exemplified in particular states of society: they are struggling with prejudices which tend to repress them, and emerging from the midst of circumstances which for a while weaken their influence. They are, however, accommodated to the taste of the nation at the time; and a premature reformer would in all probability rivet the chains of prejudice, or ensure his own destruction; whilst he who watches the tide of public feeling, and seizes the proper moment for innovating on public opinion, will carry the whole nation along with him in a triumphant career of improvement, and will lay the foundation of principles and feelings which will never cease to operate till the nation shall cease to exist.

We are often astonished to see how slowly and reluctantly some of the most obvious principles of political morals are recognised. The Lacedemonians put to death the prisoners whom they took at Ægos Potamos, though they were fighting the battles of their country. Indeed the most refined of the ancient nations generally acted on the most contracted principles of political expediency; and we more frequently meet with instances of generosity in the case of a successful despot, than in that of a free and high-minded people. How long was it before the principles of civil liberty were understood, and how imperfectly are they still understood, over the greater part of the world. Yet nothing can be more obvious that the foundation on which they rest. It is evidently this, that no man has a right to restrain the freedom of another, so long as he does not use it in a way injurious to the public interest. Yet this principle is counteracted by the love of power which every man feels, or by the advantage which he may derive from supporting a successful usurpation. In consequence of these conflicting principles, there is a constant struggle between the love of freedom on the one hand, and the love of power and the servility of interest, on the other; and even when freedom prevails, it cannot temper its own triumphs, but, by running into licentiousness, subverts its own rights, and often produces a prejudice in the mind against its fairest claims.

But whilst we contemplate the gradual and imperfect evolution of the moral principle in various states of society, we see at the same time the beauty of God's moral government, which makes the same principle which consolidates the rudest states cement the most polished and the most powerful; expanding with their growing wants and their advancing knowledge, till at last it gives birth to feelings, of which the ruder mind could form no conception. Such a view is surely well calculated to produce liberality and mutual forbearance. We might almost as well find fault with a man for being born blind, as with an illiterate savage for not feeling the finer moral sensibilities of our nature. The faculty is not yet developed, because no excitement has been applied to it; and the individual thus circumstanced is like a child who has an ear for music, but, from want of experience and training, cannot as yet distinguish one tune from another. And the same estimate which we apply to the moral state of nations, we ought likewise to apply in judging of the characters of individuals. How often do we see incongruities which we lament, and which yet do not, on a fair estimate, amount to moral delinquencies! They arise rather from some obliquity of the understanding, which has been disturbed by inveterate prejudice, or fettered by invincible ignorance: and we ought to regard persons thus unhappily situated, with the same indulgence as we view nations a century or two behind our own, in point of general improvement. In fact, every individual, in his moral progress, has to go through all the stages which have conducted nations, during the lapse of many centuries, to their highest pitch of moral and political improvement. We see him, for instance, at one time distinguished by the prejudices which characterized the tenth century. We see him struggling, with difficulty, through the mists of ignorance, till at last some event, similiar to the revival of letters, or the art of printing, or the Reformation in religion, agitates his mind, rouses his faculties, and raises his feelings to the highest tone of moral refinement.

Hitherto our attention has been directed almost solely to those great general principles which God has established in the constitution of our nature, or the arrangements of his providence, to direct us in that course of duty which is most consistent with his will, and with our own happiness; and we have endeavoured to show that we are evidently directed, and to a certain extent forced into the path which we ought to follow, in fulfilling the will of Heaven, and prosecuting our own happiness. Our object has been to show that the principles of morals, so far from being accidental or conventional, are fixed and immutable; varying occasionally so far as the exhibition of outward actions is concerned, but permanent in their nature and character. Our instincts, our appetites, our bodily powers, our mental faculties, together with the whole constitution of nature, point to the same goal, and conspire to produce the same important results. Experience and observation confirm these obvious intimations, by showing us that *what we ought to do*, is always most consistent with our happiness and interest, and that whenever we violate the invariable order prescribed and confirmed by so many sanctions, the transgression never fails to bring its own punishment along with it, and to remind us of the eternal law by which our moral actions and feelings should be regulated, and shall one day be judged.

But whilst our duty is thus enforced by so many considerations, it must at the same time be remembered that all our feelings have a tendency to excess; that every passion seeks its immediate and direct gratification; whilst such indulgence is in general utterly subversive both of happiness and moral order. Hence the unceasing conflict between our passions and our reason, in which the latter is so often worsted; and hence all those moral evils which desolate the world, which introduce guilt into the conscience, and misery into the abodes of men. To obviate these inconveniences, is the object both of moral studies, and religious instructions, though these frequently prove ineffectual to correct the inveterate habits arising out of vicious indulgence. There is, however, no natural impossibility of doing so. Any vicious habit may be corrected, if motives sufficiently powerful are suggested. Let a man be convinced of the odiousness and criminality of vice; let him be persuaded that its evil consequences do not terminate in the present life, but shall be continued in the world to come; and show him at the same time a practicable method of escaping these evils, and it is impossible to doubt that he will readily embrace it. Men continue the slaves of sin, only because they do not see its enormity, or because they reckon their emancipation hopeless. We conceive that moral reasoning may be highly useful in enlightening the mind with regard to the first of these errors. It is more peculiarly the business of religion to remove the second; and although it does not fall within the province of this article to dwell particularly on the sanctions of religion, yet, as we think that they are most powerfully enforced by the judicious application of moral reasoning, we shall be happy if our speculations can in any degree be made subservient to this important end.

After the general view which has been given, we proceed to consider more particularly the various principles which impel the mind to action, or which influence its determinations; and in this investigation we shall necessarily be called to attend to the *moral estimate* of the actions which result from these principles.

We have seen, that though an invariable rule is pointed out by the constitution of our nature, and the arrangements of providence, yet there is no principle in our nature which directs us to the invariable observance of this rule. If there were such a principle which inclined us irresistibly to the performance of duty, we should cease to be moral agents, and accountable beings. The very idea of a moral action implies that there is a choice between motives, and the greater the struggle, the more glorious is the victory when good principles prevail. There is even among the lower animals a sort of balancing of motives arising from experience and education. A lion, for example, has always a disposition to eat a man when he is hungry; in situations, however, where he has an opportunity of being acquainted with the power and resources of man, he rather wishes to avoid him; and we have heard of a single Moor putting a lion to flight with a stick. The natural propensities of the animal are, in this instance, repressed by fear; and he, no doubt, reckons the risk more than sufficient to counterbalance the expected advantage. A dog has a natural propensity to worry a cat; but a few whippings will restrain him, and teach him to live with the animal, for which he seems to have a natural antipathy, on amicable terms. But this species of discipline does not, in the smallest degree, approach to moral culture. Punishment is associated with the action, and this induces a fear of committing it; but we have no grounds whatever to suppose, that the animal can see any thing like moral impropriety in the action; or that that there is any thing resembling conscience to restrain him.

We grant that there is just as little moral worth in human conduct, when it is disciplined solely by fear, or any other principle distinct from the perception and love of virtue. No action proceeding from any other source can ever be the object of moral approbation; and this forces us again to refer to the will of God as the great standard of moral action, and to the idea of our accountableness to him, as the grand sanction by which moral obligation is enforced; for we hold it to be utterly impossible to perceive the beauty and obligation of virtue, without perceiving that the Being who has established this fair order of things is entitled to our obedience, and that we must be accountable to him for our actions.

Of the simple principles which impel the mind to action, the first which demands our attention is *instinct;* which directs to certain actions, antecedently to all experience, and, probably, in most cases, without any knowledge of the end to be produced. The term is, in general, not used with sufficient precision. It is often confounded with our natural appetites and desires. We would distinguish them in this way, that the appetites are certain feelings of want; whilst *instinct* is the principle which directs to the means of their gratification. Thus hunger and thirst in a child, are not instincts; but suction and deglutition are. This distinction, however, is seldom rigorously attended to. Nothing can be more unphilosophical than the theory which supposes the human mind to be merely a bundle of instincts; and which endeavours to account for the superiority of man, by assigning him a particular instinct adapted to all the emergencies of his circumstances. In this notion, there is a complete confusion both of language and ideas; for if we consider instinct as the principle which, prior to experience, directs with invariable certainty to the gratification of our wants, it is evident that man is of all other creatures the least indebted to this principle for the comforts which he enjoys, and for the feelings which exalt his nature.

In order to understand this subject more thoroughly, let us consider the operation of pure instinct in the case of the lower animals, who are guided by it to all the ends for which Providence has designed them. With them, instinct is all in all. They are directed instinctively to the food which is most proper for them; they construct their nests or their habitations without the aid of a teacher; and no one ever thinks of deviating from the general form adopted by the species. The young are soon as accomplished as their parents; and the only acquisition which they gain by experience, is some knowledge of the enemies whom they have most reason to dread. This they have not by instinct; for we see the young birds, after they are fairly fledged, and capable of flying, yet allowing themselves to be approached by boys, whom, however, they soon learn to consider as their greatest enemies. In some of the South Sea islands, which have been seldom visited, the larger species of *phocæ*, as well as several kinds of aquatic birds, are perfectly fearless; experience will soon teach them to lay aside their confidence in man. This may seem to make some approach to human reason; but it is merely an exertion of memory which they possess in a considerable degree; and without which they could neither avoid the dangers to which they are exposed, nor be susceptible of that degree of education which renders them subservient to the use of man. Their acquirements, however, seem to be entirely accidental, and to depend solely on the simplest modification of memory; a faculty necessary for their existence; for it is by this that the mother must know her young; it is by this that the beasts of the forest know their accustomed lair; and it is by this that they learn to know the places most favourable for prey, and the seasons best adapted for its capture. A wild beast attempting to ford a stream where he has been carried down, and his life endangered, will not try it at the same place again. In these instances, the lower animals are guided by memory, and not by instinct; and memory to this extent is absolutely necessary for the preservation of their existence. To the same source we must ascribe all the attainments of the elephant, in so far as they are not instinctive, and all the tricks which the more sagacious animals learn in consequence of a species of education.

We believe this to be the only encroachment which the lower animals ever have made, or ever can make, on the province of human reason. The comparison of two ideas in the memory, and the perception of their relation, constitute the first link in a process of reasoning; but even this simplest of all intellectual operations, the brutes seldom, or perhaps never employ. Whilst the infallibility of their instincts, and the liberality of heaven leave them nothing to desire, they cut off the possibility of ulterior improvement. They have no need to labour for clothing; it is abundantly supplied by nature; *they sow not, neither do they reap, nor gather into barns; because their heavenly father feedeth them;* they seek no defensive armour; they fabricate no offensive weapons, because nature has amply supplied them with both. They have no need even to tax their memory, as to the food most convenient for them; for here, instinct is their guide, and tells them at once what is most proper and most agreeable.

For what purpose, then, should the inferior animals be possessed of reasoning powers? They never could be called to exercise them; for they gain their object with certainty without them; man himself would not exercise his reason, were he not stimulated by his wants, and destitute of any instinct which might guide him with infallible certainty to the attainment of his wishes. The nature of man is possessed of indefinite capabilities, from the very circumstance of his not having definite instincts adapted to every demand of his desires. In consequence of this defect, he is forced to recollect, to compare, and arrange; and this exercise compels him to discern the beautiful order and wise disposition of the visible creation; and thus to recognise an eternal source of excellence, and an Almighty Being, to whom he owes allegiance, and to whom he perceives he must be accountable far his actions.

But a brute is incapable of any researches; *inopem copia fecit.* Why should he compare, abstract, or generalize? Man does so only from necessity; in the case of the brute, this necessity does not exist; for instinct directs him at once to the object best suited to gratify his desires; and beyond this he cannot form a conception or a wish.

A few instances have been adduced of variable instinct, with a view to prove that human reason is nothing else but instinct capable of indefinite variations. It has been said, and we are not able to contradict it, that certain birds which build their nests among the branches of trees in ordinary circumstances, are accustomed so far to vary their plan, as to form pensile nests, hanging from the branches, in countries infested by monkies. But we have the strongest reason to suspect a variety of species in this instance. It is certain, however, that a monkey exhibits considerable variety of action; and when he cannot crack a nut with his teeth, he takes a stone to assist him. We have also heard that a crow has been known to take a shell-fish up into the air, and drop it among rocks, in order to obtain the meat within. These instances, in so far as they are well authenticated, evidently advance a step beyond the precincts of instinct. In the case of the monkey, however, it may have proceeded from imitation, for a monkey is the most imitative of animals; and if he had ever seen a human being have recourse to such an expedient, it would be readily imitated. Besides, the hands of a monkey are such important organs, and so constantly employed, that such a discovery as cracking a nut by mechanical means, must have occurred; and if it occurred once, it would be remembered. In the case of the crow, also, it might naturally happen, that she would accidentally drop a shell, and descending to recover it, she might find it broken, and the meat accessible; and we see no reason to doubt that the experiment might be repeated, on the same principle as an animal will repair a second time to the place which has yielded him the most agreeable food. We can see little more semblance of reasoning in the case of the crow, than there would be in that of a horse, who, having strayed accidentally into a field affording comfortable pasture, should repair to it again next day, and should seek out the very gap through which he had accidentally gained admission. There is nothing in all this but a simple exercise of memory, without which animals could not exist or be rendered subservient to the use of man. Had they no power of locomotion, so as never to be put in the way of danger, or did every place afford subsistence, and other gratifications, with equal facility, in that case, even memory would not be necessary; and being unnecessary, it would not be imparted, for nature bestows no superfluous gifts; but needing it, as they obviously do, for their preservation and their comfort, it is bountifully conferred; and being modified by the different habits of different animals, it exhibits many singular and surprising phenomena.

This much, then, we allow to the lower animals; and we cannot but be filled with astonishment, when we see them unconsciously accomplishing works which reason can scarcely comprehend, and which require the acutest researches of man to discern the important purposes indicated by their structures and their plans. We are forced to subscribe to the maxim, *Deus est brutorum anima*, in so far, at least, as to perceive that the wisdom and goodness of the Almighty Parent are most distinctly displayed in the unconscious instinctive operations of the lower creatures.

Instinct goes a very short way in regulating human conduct: it is useful to man, chiefly as regulating the functions necessary to vitality; but in so far as his conduct is guided by instinct, he is a necessary, and not a moral agent. To make man accountable, it is necessary that good and evil should be set before him, and that he should have the liberty of choosing between them. The choice is often difficult; because inclination draws one way, and reason and conscience another; and our strongest feelings are frequently opposed to the most obvious calculations of prudence and duty. Moral virtue consists in a man's preferring the latter; for it is then that he gains a victory over himself, and resists the propensities that would lead him astray. The lower animals are altogether incapable of forming such conclusions, or of being influenced by such motives. The prospect of immediate punishment may teach them to repress certain propensities; but they cannot perceive this to be right. On the contrary, there can be no doubt that they grumble at the necessity which compels them. But the human mind recognises a law whose excellence it acknowledges; and the human heart never feels such genuine satisfaction as when it sacrifices an evil propensity at the shrine of virtue and of wisdom.

Instinct directs the lower animals not only to the proper objects of gratification, but to the proper measure and degree of enjoyment. It performs no such decided functions in the economy of human life; for even when we know the objects of gratification, we are under constant temptations to indulge in excess, either of desires or of enjoyment; and by this means we never fail to bring misery on ourselves and others. From this source proceed all the moral evils which deform human nature, and overwhelm the world with misery and crimes. And yet it is the presence and pressure of these evils that afford an opportunity of exercising the most exalted virtues, and of advancing the moral dignity of man. It is from our being made capable of knowing good and evil, that we learn to appreciate virtue; that we recognise an eternal source of excellence; that we see the extent of moral obligation, and perceive that the destinies of our nature point to something more exalted than the gratifications of sense, or the enjoyments of the present world.

Man could not be a moral agent, if he could not do wrong: his obedience in that case would not be more valuable than that which proceeds from the instinctive impulses of the lower animals. In his state of absolute innocence, when there was nothing to seduce, when the passions were in absolute subjection, and the will had no disposition to stray; with all these advantages, he could not have been a moral agent, if he had not had an opportunity of doing wrong. Accordingly, we learn from the short but interesting account of the original state of man given in the sacred Scriptures, (an account which appears to be perfectly consistent with the soundest philosophical opinions,) that such an opportunity was afforded him. An *arbitrary* command was imposed; a *moral* restraint, in a state of perfect innocence, would have been absurd and unintelligible; but he could easily understand the impropriety of violating a positive command, which he felt he had the power to observe or to disobey. Yet still we may have some difficulty in perceiving how he should have had an inclination, in his state of innocence, to break through such a slight restraint. An evil agent is therefore introduced, who suggests temptations and inducements to sin; and he appears to be no superfluous personage in this fatal drama; for though man could have no excuse for yielding, yet he appears a fitter object of mercy, since he was seduced by the artful insinuations of another. We do not know how far we are entitled to lament this catastrophe. Without it human nature would not have been what it is: and as it is, we believe it displays the wisdom and goodness of God more fully than would have been done, had man never gone astray. But we must repress all farther speculations on this subject: if they may be indulged at all, they fall more properly under another department of this work.

It is only during the first stage human of life, that the operations of instincts are particularly observable in man: they seem afterwards to merge so completely in reason and experience, that their influence is little noticed. Hunger, thirst, and the sexual appetite, form another important class of active principles; they are common to man with the lower creatures, and are absolutely necessary for the preservation and continuance of animal life. The immediate object of these feelings is bodily gratification. They originate in the body; they terminate in the body; and are attended with uneasiness till the means of gratification are procured. They are in their own nature perfectly indifferent as to virtue or vice, but they are productive of most important moral consequences, from the pursuits to which they stimulate, from the feelings which they inspire, from the knowledge which they are the means of acquiring, or from the temperance and self-denial which they afford an opportunity of exercising.

There is a remarkable difference between man and the lower animals, with regard to the nature of the food on which they subsist. The various tribes of animals have each a particular species of food appropriated to them. This is so very observable, that it affords grounds for their classification, under the various heads of Carnivorous, Frugivorous, Granivorous, Insectivorous, &c. &c. But man is Omnivorous: he eats every thing that is eatable. This is a beneficent provision of the Universal Parent, in favour of his rational offspring; for it affords them an opportunity of multiplying, far beyond any animals of the same size, who depend solely on one species of food. Man lays every department of nature under contribution; and is thus enabled to promote the multiplication and comfort of his species, without trenching materially, if at all, on the numbers or enjoyments of the lower creatures. There is indeed every reason to believe, that the lower animals, under the dominion of man, are more numerous and more comfortable than they could have been, had they had the world wholly to themselves.

But this is not the only advantage arising from the universal voracity of man. He is perhaps not directed instinctively to any species of food but his mother's milk; beyond this all is the result of labour and experiment. He is forced to observe the qualities of the different articles of food; he thus becomes acquainted with their medicinal properties, and with their comparative value as means of subsistence. Those kinds which he finds most serviceable, he cultivates with care: this brings him acquainted with the properties of the soil, and the various operations of agriculture; and thus, whilst he seems to be solely intent on satisfying the importunate calls of hunger, he is insensibly storing his mind with varied and extensive knowledge.

And there are still more important results arising from that law which gives to man for food, "every herb bearing seed, and every tree bearing fruit, and every moving thing that liveth." Being compelled to seek what suits him best, when once he has discovered it by his ingenuity or by his labour, he concludes with the most perfect conviction that he has a right to the fruits of his discovery. Hence the distinction of property; a distinction which could not exist were no labour necessary, and did the earth produce spontaneously sufficient food to satisfy the appetite of hunger.

On the distinction of property depend many of the relative duties of life, and the greater part of the political virtues. Indeed, the maxim of *suum cuique* embraces almost all the duties which we owe to society. Thus our very wants tend to promote not only our intellectual attainments, but to advance the moral dignity of our nature. Does any one sigh for the return of the golden age, when the earth produced spontaneously all that was necessary for the life of man? Such a change would be in the highest degree pernicious, unless the nature of man were altered with the nature of things; and vice and misery banished from the face of the earth. The present state of things is exactly accommodated to the present circumstances of human nature. Our very virtues would perish, were things different from what they are. Were men rendered independent of each other, by the too bountiful provision of nature, there would be no room for the tender charities of sympathy, benevolence, and mutual assistance. In the present state of human nature, it is necessary for our improvement, that we should "eat our bread with the sweat of our brow."

The appetite of thirst also gives rise to some singular consequences, which have a very considerable effect on our moral feelings. Water is the natural beverage to which instinct directs every animal, when deprived of its mother's milk; and thirst, when not gratified, becomes the most excruciating torment. As men, in many situations, could not readily command a supply from springs, or running streams, they would naturally look out for a substitute: this they would find in the juice of fruits and succulent herbs. In attempting to preserve this as long as possible, they would find a singular change produced by fermentation; a change which made the liquor keep much longer, whilst it communicated to it new and pleasant qualities. A field is thus opened up for a new species of industry and ingenuity; and also for the exercise of a new set of moral qualities: for these newly invented liquors intoxicate, whilst they exhilarate, and remove mental depression at the risk of intemperate excesses. It would soon, however, be found, that excessive excitement either gave birth to immoral practices, which cool reason condemned, or was succeeded by a corresponding depression, which more than counterbalanced the preceding elevation. This would tend to teach moderation, and would afford another opportunity of learning those lessons of temperance and self-denial, which are alike essential to virtue and to happiness.

The sexual appetite gives birth to many important consequences, moral, physical and political. It is wisely ordered, by the Author of our nature, that this feeling does not begin to operate till reason can, in some measure, control its excesses, and till man is enabled, by his own labour, to support his offspring. Were it to operate sooner, there would be an excess of population, without the means of subsistence; and the mind and body would be alike enervated, and unfitted for the attainment of those useful qualities which are necessary for the business of life. In man this appetite gives birth to love, with all its tender associations and endearments; a passion totally unknown to the lower animals, in its more refined sense, but which, in the human species, stimulates the mind to the most noble exertions, or enriches it with the most amiable feelings, or soothes it by the most pleasing hopes.

This appetite, in the lower animals, is gross and evanescent, being easily satiated with periodical gratification. In man, the attachment being founded on mutual esteem, and valuable mental endowments, and the stimulus being not periodical but permanent, the connexion between the sexes is, in its very nature, calculated to be lasting; and hence arises the permanent connexion of marriage, which, in almost every country, is considered as indissoluble, except by the death of one of the parties.

But besides this there is another reason, founded in the very constitution of human nature, why the marriage contract should be indissoluble. For who is to support the offspring, during their long immaturity, if the connection between the parents be dissolved? Promiscuous concubinage would soon dissolve all the charities of life, and undermine the pillars of society. But marriage keeps alive the parental feeling, by keeping the child in the presence of its parents; and this again strengthens the attachment between husband and wife, by placing before their view the pledges of their mutual endearments. In the case of the lower animals, the first of the offspring is always independent before another is produced: in the case of man there may be a dozen dependent children at once, in different degrees of helplessness; for additional offspring is produced before the former is independent: and thus a succession of ties strengthen the matrimonial connection; and a thousand feelings are generated in the mean time, which bind man not only to his family, but to his species.

It has been supposed by some that there is a congregating propensity in man, as among other gregarious animals; and that he is driven instinctively to desire the society of his species. Others again suppose him to be completely anti-social, and that he is induced to seek the fellowship of his species, merely as the means of defence against animals more powerful than himself.—Whenever we find two opinions on the same subject diametrically opposite to each other, we have reason to conclude that neither of them is exactly true; or, at least, that they have not been stated with sufficient explanation or qualifications.

We do not think it possible to prove that there is in man a principle similar to that which operates in gregarious animals, in making them desire the society of their species. There is, indeed, in man a strong social propensity, which results necessarily from the constitution of his nature, but is not, we believe, an ultimate principle. Suppose the whole human race to have sprung from one pair, and give to this pair a more than ordinary degree of longevity; and you see at once a complete system of society, and the origin of civil polity, arising out of the conjugal connection, consolidated by parental and filial ties, and gradually extending its ramifications till a tribe or nation is constituted, acknowledging a common principle of association, and tracing its origin to the same head.

In this view of the subject there is a necessary, but not an instinctive principle of association; and society will be found to be held together by rational, yet unavoidable ties, since our natures are so constituted, and our circumstances so disposed, that we cannot but feel their obligation.

The opinion which supposes men to have associated merely from the conviction of their own helplessness, is still more untenable than that which ascribes their association to a gregarious instinct. This conviction may be a very good additional reason to keep them together, but it never was the principle on which any society was originally formed. Man is born in society, and trained to the love of society by numberless powerful associations: it is only in society that his powers can be evolved, and his faculties called into exercise: we may therefore conclude, with certainty, that this is the state for which he was intended by the author of his nature, and that the social system is not the result of accident, but of infinite goodness and unerring wisdom.

When society is widely extended, common laws and common religious principles are brought in aid of the natural bonds of union, which are apt to be lost sight of in the midst of complicated political connections. In such a state men scarcely look beyond the artificial regulations which apply to their immediate conduct, and are apt to think that society is a work of human invention, arranged and methodized by the wisdom of some political sages. The hand of man may, indeed, be seen in every well regulated society; but it is only to give strength and efficiency to those great natural principles which have their origin in the contracted sphere of family connection. All artificial and political regulations depend on these principles, and derive their obligatory sanctions from them; in the same manner as artificial signs in language derive their power and significancy from those which are natural. "There is such a natural principle of attraction in man towards man," says Butler, "that having trod the same tract of land, having breathed in the same climate, barely having been born in the same artificial district or division, becomes the occasion of contracting acquaintances and familiarities many years after; for any thing may serve the purpose. Thus, relations merely nominal are sought and invented, not by governors, but by the lowest of the people, which are found sufficient to hold mankind together in little fraternities and co-partnerships: weak ties, indeed, and what may afford fund enough for ridicule, if they are absurdly considered as the real principles of that union: but they are, in truth, merely the occasions upon which our nature carries us on, according to its own previous bent and bias; which occasions, therefore, would be nothing at all, were there not this prior disposition and bias of nature."

Besides the instincts and appetites common to man with the brute creation, and which are absolutely necessary for the preservation and continuance of the species, we are conscious of desires of a more dignified nature, which raise man far above the lower animals, and carry him forward in the career of indefinite improvement. We do not think that the number of these desires can be distinctly specified. Dr. Reid has mentioned the *Desire of Power*, the *Desire of Esteem*, and the *Desire of Knowledge;* to which Mr. Stewart has added the *Desire of Society* and the *Desire of Superiority;* and we see nothing to hinder others from extending the enumeration. These philosophers consider the desires which they have specified as ultimate and instinctive principles of our nature: to this we cannot assent, without altering the usual acceptation of language. We have already said that we do not consider the desire of society as an instinctive principle, but as arising necessarily out of the ordinary circumstances of human nature. That which is instinctive cannot be counteracted. But we conceive it perfectly possible for a mother to fly from society, to train her child in solitude, and teach him the arts of savage independent man; and we think there is every probability that a child thus trained would grow up in fear and hatred of his own species, till perhaps the sexual appetite drove him to desire a more intimate acquaintance with them. But, man born in society, and growing up amidst the extending ties which strengthen the social union, is led, both by education and habit, and feelings, to desire the company of his species.

The *desire of knowledge* is generated in the progress of society, but we do not desire it till we find that we cannot do without it, and the majority of mankind are satisfied with a very moderate portion. When the savage has knowledge sufficient to manage his weapons, or to match his enemy in stratagem, he feels no violent *orexis* impelling him to farther acquisitions. We do not, therefore, regard the *desire of knowledge* as an instinctive principle: we consider it rather as a rational desire, recommended by its perceived utility; for though a certain degree of knowledge is necessary in every stage of society, and is, in fact, unavoidably acquired by our intercourse with material objects, and by the results of experience, yet the desire of knowledge, for the sake of knowledge, operates only in an advanced state of human improvement.

That the *desire of power* is a natural and universal principle of our constitution cannot be denied; nevertheless, we conceive it to be unphilosophical to consider it as original and ultimate. It is quite evident that man feels himself in want of many things; and nothing can be so welcome to him as the means of procuring them. On this is founded the desire of power, the only object of which is to supply the wants and desires of our nature. This desire of power, then, as it has been called, is nothing more than a desire to have the means of procuring the enjoyments which we think necessary for happiness; and hence it is manifested in a great variety of ways, according to the views which men have formed of enjoyment. If knowledge appears the most likely means of advancing our character, or of securing any desired pleasure, we eagerly seek knowledge. In this case, those who have never heard of the name of Bacon act under the influence of his maxim, that *knowledge is power*. If sensual indulgence be the prominent desire, the means of gratification are sought with no less keenness; and hence the desire of riches is generated, as these seem to be the most convertible means for procuring varied enjoyments.

But, in the progress of mental improvement, some may perceive that a man's happiness consists as much in the limitation of his desires as in the extent of his gratifications; hence, they seek their security in self-control and in the government of their passions, adopting as a maxim, *Non desiderare jucundius est quam frui.* These persons, as Cicero observes, are animated by the same principles which impel to the most arduous enterprise of ambition, the object of both being *Ne qua re egerent.*

Such principles as these, however, can only operate in a considerably advanced state of mental refinement. In the first instance, the appetites are clamorous, and it is the first desire of every man to gratify them in the way which they seem to point out. This gives rise to a thousand varied exertions, and to numberless experiments and disappointments, which often produce much misery both to the individual and to society. But the result, upon the whole, is salutary; the stock of knowledge is increased, the moral discipline of the species is promoted, and a wise man will recognise an overruling Providence, when he sees the general order of the world maintained inviolate, amidst the confusion of human passions.

If any one of our desires could be entitled to rank as an ultimate principle in our nature, we should think the *desire of esteem*, or of being loved, might claim that distinction. It operates powerfully and universally, and yet it is easy to see how it is generated in the infant mind by the caresses of the parent and the advantages which accompany them. The child perceives that his happiness depends on the good will of his parents, and therefore it is impossible for him not to desire it. The feeling expands with advancing years, and, as we are formed to be dependent on each other's exertions, we perceive that we cannot be independent of each other's esteem. Let it not, however, be supposed, that we consider the desire of esteem as factitious or accidental. We admit it to be a natural, universal principle of our constitution, as much so, indeed, as the ideas of *right* and *wrong*, *virtue* and *vice*, which, though not innate or instinctive, are nevertheless forced upon us by the condition of our nature, and by the circumstances in which we are placed.

There are some philosophers who seem to think that we detract from the dignity of human nature, unless we allow to man a set of original instincts and feelings, totally distinct from those of the lower animals. We, on the contrary, think that it is most for the honour of man to make him almost wholly a *rational* being; for, in proportion as he is guided by instinct, he is a necessary agent; it is only as a rational being, capable of weighing motives, that he can be the subject of moral discipline, or responsible for his actions. Others, again, think it derogatory to the honour of the Creator, to allow any influence to man in the fabrication of his fortune, or the formation of his character. All that we contend for is, that though God has established immutable laws, which no effort of man can alter, yet we are permitted to resist them so far as to create a temporary confusion, or local derangement, or even to ruin our own happiness, whilst yet the general order of things remains perfectly unaffected by our madness.

Mr. Stewart distinguishes between the appetites and desires, by saying that the latter are not occasional like the appetites, nor do they, like them, take their rise from the body. Our desires are, no doubt, some degrees removed from the grosser elements of appetite, but no small number of them originates in the ordinary appetites of our nature, and there, too, with the bulk of mankind, they terminate. Others of them originate in our bodily senses, and have for their object the gratification of feelings immediately connected with these senses.

We believe that Mr. Stewart, who seldom errs but on the side of excessive caution, was afraid lest some dangerous consequences should be deduced, from referring the origin of our desires to the appetites and senses. For, as Locke's Theory of Perception has been adopted by materialists, who maintain, that if all our knowledge be by sensation and reflection, there never can be any thing in the mind but the ideas of sensible objects, so it might be said, that if our desires originate in the appetites and senses, the gratification of these must constitute the ultimate and legitimate object of human enjoyment. But as Mr. Stewart has qualified Locke's doctrine, by saying, that though certain kinds of knowledge cannot be referred immediately either to sensation or reflection, yet these principles furnish the occasions of acquiring all our knowledge, so he might have said, that the appetites and senses furnish the occasions of exciting the various desires which actuate human nature. Not that we would absolutely assent to this doctrine, though it is evident that it must be very generally applicable.

We have already said, that the feeling of want creates the desire of power; and knowledge, riches, honours, public applause, &c., are only modifications of power, or means of procuring what we desire. We might conceive the desire of these things, therefore, to originate in the bodily appetites, as these give rise to the pressing wants of our nature. But, besides this, an extensive class of desires has its origin in the gratifications required by the different senses. The eye, the ear, the taste, the smell, and, in a smaller degree, the touch, have each their specific gratifications; and, hence, there is room for indefinite, or almost infinite, objects of desire. The ear gives rise to the pleasures of harmony, it enables us to appreciate the pathos of poetry and of eloquence, and all the delights of human converse: the eye gives rise to painting, statuary, architecture, and all the imitative arts.

From the same source are derived our conceptions of grandeur and sublimity in the works of nature, and also those ideas of proportion and relation which give rise to the mathematical sciences. The taste, and the smell, do not give birth to any intellectual ideas, but they suggest numberless objects of desire, to stimulate the activity of rational beings, and thus to put them in the way of acquiring knowledge, when they are only seeking sensual gratification.

But though it is quite evident that a very numerous class of our desires must be referred immediately to the body, as they have for their object the gratification of the appetites or the senses, yet we admit most readily, that what may be called the moral desires of our nature, must have a different origin. The desires connected with the senses, though they lead to the most extensive knowledge, and to the most elegant and wonderful attainments, yet do not constitute a single element of moral feeling. They may, indeed, be rendered highly subservient to morals, as means, or instruments; for extended knowledge should make us better acquainted with the laws, and the Lawgiver of the universe. But, in themselves, they are wholly indifferent as to virtue or vice; they may be converted to either, according as they are improved or perverted, and a man who is an adept in all the attainments of science, or of art, and nothing more, is yet a stranger to the noblest feelings, and best hopes of our nature.

We are, indeed, firmly persuaded, that nothing but the idea of God, and the conviction of our accountableness to him, can raise us above the importunities of appetite and the gratifications of the senses, or teach us to delight in feelings and contemplations, of which, without this idea and conviction, we never could have formed a conception. These impressions respecting the government of God, do not originate in the senses, yet they are not foreign to human nature. We have shown elsewhere, that the idea of power originates in our own conscious energies; (see Logic) after this, one link only is necessary to connect our thoughts with God, and we are compelled to admit his existence, his power, and his government, as soon as we perceive that the power of man could not make or sustain the universe. Our ideas of God, acquired in this way, will, indeed, be very imperfect; but they exhibit the elements of that more perfect science which revelation has made known.

It is here, then, that our moral character commences, for we now recognise our obligations to obey the laws of the supreme Lawgiver, and perceive it to be our paramount duty to seek to know his nature and his will. In this investigation we must soon discover, that he is totally free from the solicitations of sense and appetite, that his goodness flows unconstrained, and untainted by selfish feelings, to every thing that lives. We see it to be our duty to imitate him, and perceive the resemblance to be more complete, in proportion as we emancipate our minds from sensual gratifications, and raise them to the contemplation and love of that excellence which is inherent in the nature of the God whom we worship. It is then that we perceive a pure and adequate motive for the practice of the sublimest virtues, for we see that they are necessary to constitute our resemblance to the Parent of the universe, without which we cannot expect to be the objects of his love.

It is true, indeed, that men are trained to the duties of moral agents by the laws and institutions of the country in which they live. But these can only produce external conformity; the principle of obedience is founded in a recognition of the wisdom of the divine law, and in an admiration of the excellence of the divine nature. When the laws of men correspond with what we see so conspicuously displayed in the arrangements of Providence, they have the force of a divine sanction; when they have a contrary tendency, we pronounce them to be injudicious and oppressive, though fear may enforce a reluctant submission.

Human laws, then, borrow their influence, and derive their sanction from their conformity to the visible arrangements of heaven, and without connecting them with these as their foundation, they never can train the mind to moral feelings, nor inspire a love of the *pulchrum et honestum*, abstracted from temporal advantages. The conscience, indeed, may acquire a sort of artificial influence, from circumstances of education and early associations. But it is then little better than a prejudice, useful, no doubt, to the general interests of society, but not yet exalted to the dignity of a moral principle.

A well-informed conscience is unquestionably the best safeguard to virtue; a conscience under the influence of superstition or ignorant prejudice, is the most powerful instrument of mischief; a timid or a ticklish conscience will render the life miserable, and the conduct vacillating and uncertain. Thus, though conscience pronounces decisively on the subjects which come under its cognizance, yet another principle is necessary to determine whether its decisions be correct. On this account we have considered it, (see CONSCIENCE) only as a particular modification of the principle of moral approbation or disapprobation, directed solely to the examination of our own feelings and conduct, and increasing in an astonishing degree our happiness or misery, according as it leads us to approve or condemn our own actions. When its intimations coincide with that *amour propre*, which is natural to every human being, it enhances our happiness in the highest possible degree, as we then feel as if we had some good grounds for that self-partiality which we are so much inclined to indulge. But when, on the other hand, it pronounces our condemnation, it sinks us in our own esteem, and thus infuses a feeling of misery, such as all the opposition and reproaches of the world will not produce, whilst we stand well with our own consciences.

The principle of conscience, then, we conceive, derives its influence, not from being possessed of any independent, autocratical power, but from a conviction that we are continually in the presence of God, and must be accountable to him for our actions. This is unquestionably the ultimate and only safe foundation of its operations: and, therefore, we conceive it to be legitimate reasoning to infer the being of a God from the operations of conscience, as we do not see any rational grounds for them apart from this consideration. The ancient moralists, indeed, like many among the moderns, held conscience to be an ultimate, and not an inferential principle, and have given us most beautiful illustrations of its power over the mind of man. There is not, perhaps, to be found in any language a more powerful description of its effects, than occurs in the thirteenth satire of Juvenal: yet he never once alludes either to the belief of a God, or of a future state, as lending to conscience its chief sanction and authority. This is quite consistent with the view which he took of the independent power of conscience: and we have no doubt that it does frequently operate most powerfully, without referring immediately to such considerations: But we have as little doubt, that when its operations come to be analysed, the terrors and strong emotions which it produces will appear to be only superstitious bugbears and idle prejudices, if we separate it from the belief of a God, and a state of retribution.

Besides our appetites, which are necessary for the preservation of life, and the continuation of the species, and the various desires which take their rise from them, or from the bodily senses; we are conscious of other feelings, which have been called affections, and which are supposed to be distinguished from the appetites and desires by this circumstance, that our fellow-creatures are always the objects of them. They are called benevolent or malevolent affections, according as we feel a desire to promote or obstruct the happiness of others.

As there are certain objects which offend or gratify the external senses, so there are certain exhibitions of conduct and feelings peculiarly offensive to our moral perceptions, and which produce a sensation of dislike or abhorrence infinitely stronger than can arise from any affection of the senses. We believe this to be the origin of the *malevolent affections*, although this moral dislike and aversion does not absolutely amount to malevolence, as it is possible to feel such dislike, without hostility to the person who excites it. It is seldom, however, that this is the case; and the dislike which we feel towards moral agents most commonly produces in our minds hatred, and the whole train of malevolent affections.

Perhaps none of our natural feelings are *directly* malevolent. Anger is undoubtedly the original feeling, on which malevolence may be very easily engrafted; but this is not a necessary consequence, otherwise the injunction, *Be angry and sin not*, could never proceed from the religion of peace. Envy, jealousy, and revenge, are *directly* malevolent; but they are superinduced qualities, originating in the perversion or abuse of innocent or indifferent natural feelings. Butler, in his first Sermon on Human Nature, observes, that "as there is no such thing as self-hatred, so neither is there any such thing as ill-will in one man towards another, emulation and resentment being away; whereas, there is plainly benevolence, or good-will: there is no such thing as love of injustice, oppression, treachery, ingratitude; but only eager desires after such and such external goods, which, according to a very ancient observation, the most abandoned would choose to obtain by innocent means, if they were as easy and as effectual to their end."

We do not mean to vindicate human nature from the charge of malevolence; that such a quality exists, is proved by fatal experience; and we presume it will not be difficult to show, that it rises necessarily out of the circumstances of human nature.

Though natural objects may excite our disgust, yet we never view them with malevolent feelings. We do not consider them as objects of blame, because we know that they are not answerable for the offensive qualities which they possess. There is no volition in the injury which they inflict, and there is no *malus animus* towards the sufferer: it is this which constitutes the essence of an offence, and where this is wanting, however much we may be injured, reason says that we ought not to be offended. We view the hostility of a tiger with nearly the same feelings; we consider his rage as indiscriminate; and though we fly from him with terror, yet we do not view him with malevolence. If a dog, however, or other animal, should single out an individual, and, direct all its fury against him, whilst it is courteous to every other person, that individual could not avoid feelings of irritation, hatred, and malevolence: he would regard the animal as a personal enemy, and would rejoice in its destruction.

This is nearly the form which malevolence assumes when directed towards a human being; and, from the circumstances and constitution of our nature, we believe it to be impossible to avoid every degree of this feeling. It is impossible not to dislike those who have injured us without provocation. But this feeling of dislike does not amount to a moral offence. We may even go farther than this without offence to good morals; for when we see a person anxiously seeking opportunities of hurting us, and employing his power, wealth, and influence, to accomplish our ruin, we conceive that we may rejoice without blame, when his power, wealth, influence, and every means of annoyance which he employed against us, are destroyed. We cannot but feel *ill-affected* towards such a person; yet we are not guilty of malevolence, considered in the light of a moral offence, unless we feel a rancorous and excessive desire for the destruction of our enemy.

Our dislike of objects naturally offensive or dangerous never amounts to hatred: we only seek to avoid them; and, therefore, carefully shun the situations where they are likely to be found. But when we have enemies in human shape, and in human society, this cannot be done; we can only fortify ourselves against their arts by counteraction; and we are compelled to seek our own security by exposing the malignity, hypocrisy, and worthlessness of our enemies. This has all the appearance of malevolence; and, in general, it soon actually becomes so: for as love begets love, so there are few minds in which hatred does not produce hatred, and offence the desire of revenge.

It has often been observed, that the malevolent passions are always accompanied with painful feelings to those who indulge them. This has been considered as a wise arrangement of Providence, to impose a restraint on qualities so obviously injurious to the peace and happiness of society. The argument is not weakened by showing that melevolence must necessarily be accompanied with pain, if the account which we have given of its origin be correct: for it evidently originates in *fear* or in *dislike;* and whilst these qualities are present to the mind, it would be as impossible to feel comfortable, as it would be to remain perfectly undisturbed in the presence of a wild beast which we fear, or in the midst of noxious and offensive objects, which our souls abhor.

Whilst, then, we admit that there is a vast deal of malevolence in the world, yet we think that it is not so much a native principle, as the corruption and abuse of feelings naturally indifferent, and capable of being applied to very different ends. At the same time, we do not imagine that there is the slightest chance that this perversion can be avoided. We have the highest authority for stating that *offences must come:* they are often unintentional on the part of the offender; they may arise from his ignorance of our feelings, our characters, or our circumstances. We, on our part, are perhaps equally ignorant of his feelings and intentions: we are, therefore, always apt to confound injury with injustice, and to ascribe the evils which we suffer to bad motives, on the part of him who is the cause of them; and we believe it to be impossible, in the ordinary circumstances of human nature, not to feel ill-affected towards those who have caused us pain and suffering. Opposite feelings may indeed be implanted, and high Christain principles may teach a man to love his enemies, and to do good to them that hate him. But the ordinary feeling of human nature is, to hate them who hate us,

——Vindicta bonum vita jucundis ispa.

The heathen moralists were not agreed on this subject. Some of them considered revenge not only as allowable, but praiseworthy. Of this number are Aristotle and Cicero. The former says, that it is the property of a slave to put up with an injury. (Ad Nicom. iv. 11.) And Cicero glories in cherishing the feeling of revenge. *Odi hominem et odero, utinam ulcisci possem.* (*Ad Att.*) Some of the ancient moralists, on the other hand, pointedly condemned revenge. (See the authorities collected by Grotius, De Verit. l. iv. c. 12.) It is sufficiently evident, however, that they were not possessed of any principle of sufficient efficacy to enforce the doctrine of forgiveness. Juvenal declaims eloquently against revenge; but his argument is rather satirical than solid: it is because revenge is chiefly the passion of a woman.

——Quippe minuti
Semper et infirmi est animi exiguique voluptas
Ultio. Continuo sic collige, quod vindicta
Nemo magis gaudet quam femina. *Sat.* 13.

Though we have expressed a doubt whether any of our natural feelings be, in the first instance, decidedly malevolent; yet we have pointed out a fertile source from which malevolent affections may, and in the ordinary circumstances of our nature, must proceed. For the purposes of *parænetical* exhortation, it may be most useful to take the passions in their matured state, and, without attempting to trace their origin, to point out their consequences. But as our object is analysis, rather than moral suasion, we have all along deemed it necessary to mount as far as possible to first principles, and to show the steps through which the feelings pass, till they reach their decided character of virtuous or vicious habits or affections. It is the same thing as to the practical result, whether malevolence be considered as an original feeling, or as resulting necessarily from the circumstances in which we are placed: but it is not the same thing as to arrangement; that being always the best which approaches nearest to elementary principles, as it enables us to trace more completely the progress of the vicious affections, and to detect the circumstances which have nourished and matured them.

The benevolent affections are original feelings, flowing immediately from principles implanted in our nature. The benevolent affections enumerated by Dr. Reid, are parental affection, gratitude, pity, esteem of the wise and good, friendship, love, and public spirit: to which Mr. Stewart adds filial affection, and affection of kindred. It is obvious, that, on this plan, the enumeration may be considerably extended; but this would only be tracing the ramifications of one or two original principles, which assume different aspects according to the circumstances in which they are exhibited. It would be to confine our attention to the branches, the foliage, and the fruit, without considering the root by which they are nourished; or the cultivation which is necessary to render them fresh and vigorous.

Of the benevolent affections decidedly original, are love and parental affection; these lead us at once, without reasoning, and without calculation of consequences, to desire the happiness of those who are the objects of them: and we believe, that from these two, most, if not all, the other benevolent affections may be derived.

The love of a parent to his child is irresistible: it is a strong constraining principle, alike imperative on man and the greater portion of the brute creation. Some among the ancients imagined that there was a kind of undefinable feeling which they called στοργη, inclining the hearts of parents and children to each other, though from any accident their features and persons should not have been previously known. This notion now seldom finds a place, except in the dreams of romance. But though the feeling be divested of those mysterious powers, which some, who had more imagination than philosophy, once ascribed to it, it is still sufficiently prominent, and asserts its decided claim as one of the strongest original feelings of our nature.

The parental feeling is powerfully manifested in the lower animals. Every boy must remember how artfully he has been misled by the partridge, the snipe, the lapwing, or the wood-pigeon, when they feigned distress, and exposed themselves to evident danger, for the protection of their young. A hen, proverbial for cowardice, will attack the most formidable mastiff, when he comes too near her brood; and it is curious to observe the intimidating effect of rage, even when devoid of strength: the most powerful animals often shrink from the feeblest assailant, when it is armed with the reckless courage inspired by parental affection. We have seen a sheep fairly beat off a fox who attempted to seize her lamb. And as a farther illustration of the power of parental affection, and of the intimidation or respect which the courageous display of it inspires into the most powerful animals, we may mention a recorded fact which must be familiar to many readers. A lion, who had broke out of a *menagerie* in a town in Italy, seized a child whom he found in the street, and was carrying it off: the mother perceiving the circumstance, threw herself, in a frantic manner, before the lion, and loudly demanded her child. The animal, astonished or terrified, dropped his intended prey, and allowed the distracted mother to carry off her child in safety.

In man, indeed, the parental feeling derives additional force from the principle of association, and a thousand adventitious aids are brought into action, to strengthen and confirm its power. We may, nay, we must become more attatched to our own children than to the children of others, were it for nothing else than the mere frequency of intercourse: and as soon as we see our caresses appreciated, and our anxious desire to please repaid by a smile, an additional bond of endearment is created, and a mutual interchange of love is established.

We wonder that this was not perceived by the accurate Dr. Reid to be sufficient to account for the strong affection which a nurse entertains, even for a child that is not her own. "It is very remarkable," he observes, "that when the office of rearing a child is transferred from the parent to another person, nature seems to transfer the affection along with the office. A wet nurse, or even a dry nurse, has commonly the same affection for her nursling as if she had born it. The fact is so well known, that nothing needs be said to confirm it, and it seems to be the work of nature."* It is indeed the work of nature, acting on the infallible principles of association: but, in its origin, it has nothing akin to parental affection, which is an inborn, not an implanted quality, and which may be strengthened by various associations, though it is not generated by them.

The desire of founding a family, and transmitting a name to posterity, may operate with some as an inducement to pay particular attention to the rearing of their offspring. But these are only secondary considerations; and the feeling operates in full force, where they are unfelt and unknown. For even when the prospect of a family presents nothing but additional burdens, and accumulated cares, yet even then the parental feeling is twined round the heart; and that man would be reckoned little better than a monster, who would hesitate to risk life itself for the safety of his child.

But though this principle can exist in the midst of poverty and misery, it may be weakened, and sometimes wholly obliterated, through the prevalence of luxury, or the love of pleasure. The sanctioned frequency of infanticide among many nations arises from the parents finding their children an obstruction to their individual gratifications. On this principle is founded the society of the Arreoys in the South Sea islands: the society is, or rather was, held in the highest respect, and all who became members of it were bound in the most solemn manner to destroy all their children. An instance is recorded of a member of this society being married to a daughter of one of the kings, by whom he had eight children, who were all murdered in succession, without the slightest imputation of blame. We are happy to record the triumph of Christianity over this most barbarous and inhuman practice.†

It is not only among the ignorant and uninformed votaries of pleasure that this subversion of parental affection has been witnessed: it has often been found to exist to a most disgraceful extent, during periods of the highest intellectual refinement: for nothing is sacred to the love of pleasure; it prostrates every generous affection, and erases from the human heart those characters which were engraven on it by the hand of its Maker. Strong as the parental feeling is, then, we may see the necessity of every accessary aid that can be brought into action, to maintain its influence against the deadening effects of luxury, and the love of indulgence. And Providence, in its wisdom, has furnished such aids. In fashionable life, children are little regarded; and if they sometimes appear less spoiled than the children of the lower orders, it is only because they engage less of the attention of their parents, and thus accidentally escape that injudicious kindness which renders them intractable and disobedient. A fashionable mother cannot submit to the drudgery of nursing her child; and a fashionable father would give himself very little trouble about his instruction, were it not to support the eclat of a name, and to inherit the family for-

* Active Powers, p. 151, 4to.

† Christianity is now (1819) the acknowledged religion of all the islands under the command of Pomare, King of Taheite.

tune and honours. We believe, indeed, that were it not for such considerations as these, there would be few children among the lovers of pleasure to make any demands on parental affection.

Juvenal gives a horrible account of the practices which were adopted in his time, to avoid the incumbrance of a family. His unvarying malignity to the fair sex might render his testimony suspected, were it not borne out by other evidence.

> Sed jacet aurato vix ulla puerpera lecto :
> Tantum artes hujus, tantum medicamina possunt,
> Quæ steriles facit, atque homines in ventre necandos
> Conducit.

But the powerful feeling of parental affection is weakened or destroyed, not only by the prevalence of luxury, or the love of pleasure ; it might also be endangered by the necessitous circumstances of the parents, were there not counteracting considerations to induce the rudest and most wretched tribes to rear and protect their children. Among savage nations, children would be in danger of being neglected, as the love of ease might get the better of parental affection. But this is counteracted by the consideration, that the strength of their family or their tribe is to be advanced by the children whom they rear. And that this consideration is more powerful, in many instances, than parental affection, appears from this, that among savage nations none but healthy and well-formed children ever arrive at maturity : from which we may naturally infer, that the weakly and deformed are either exposed, or allowed to perish through neglect.

Love is an affection decidedly benevolent, as it leads us directly to desire the happiness of the person whom we love. Love cannot exist but between persons of different sexes ; it is therefore evident that the sexual passion is a strong element in its composition. We, indeed, extend the meaning of the term ; and when we feel any strong partiality for a person, arising either from gratitude or from the perception of amiable qualities, we are said to love him : and we believe, in fact, that there cannot be love even between the sexes, unless it be founded on some real or supposed mental excellence. Where love really exists, the desire of enjoyment is always accompanied with esteem of the person beloved : without this it is mere brutal appetite.

Beauty is, perhaps, the principal attraction ; it is often the only one that seems to be recognised. But if we proceed to analyse this magical quality, we shall find that it owes its influence chiefly to the idea that the face is an index of the mind ; and that the perfection of beauty is always supposed to imply the perfection of amiableness in character and disposition. Every heroine of romance is always a paragon of beauty ; and no writer has yet had sufficient confidence in his own powers, to attempt to interest his readers in behalf of an ugly woman. All this proceeds on the idea, that beauty is generally accompanied with some amiable or exalted mental qualifications.

If this is a prejudice, it is at least one that has some foundation in nature : for it cannot be denied that ugliness is generally accompanied with some qualities not particularly amiable. We do not, however, pretend to affirm that this consequence is the necessary result of the mal-conformation of the countenance or person. It may be easily accounted for on other principles. The ugly person may be chagrined by the unkindness of nature. She may feel indignant to see incense paid to beautiful insipidity ; whilst she, with an inferior face, but with vastly superior qualifications, may be scarcely able to command common politeness. Thus, the neglect with which an ugly woman is too generally treated, may sour her temper, and diminish her benevolence : and after she has been driven by the injustice of the world to put herself in a posture of self-defence, or defiance, she is accused of being naturally peevish, envious, and malignant.

We can see no reason why she should be naturally more deficient in amiable qualities than her fairer rivals ; and were she treated with the same respect, we have no doubt that she would show the same amiableness of disposition. And, certainly, a plain-looking woman, perfectly amiable and unenvious, would present a phenomenon of excellence, which, from its rarity, may justly be deemed more dazzling than the most splendid beauty.

But, besides the beauty of external features and form, love is kindled by an indefinite number of qualities which have taken hold on the imagination of the lover, and which he regards as the sure signs of every desirable excellence. These qualities are extremely various, according to the particular views, habits, and feelings of individuals, into which we do not, at present, mean to enter ; and the only object which we have had in view in this discussion respecting the origin of love is, to show that, in the proper acceptation of the word, it cannot exist but with the perception, or supposed existence, of some good mental qualities in the object beloved. The mere animal passion may exist, and be gratified, without this perception or desire of excellence. But rational beings alone are susceptible of love, in the proper acceptation of the term ; and mental qualifications, real or supposed, are always essential ingredients in its composition.

In this view, the affection, or the *passion* of love, (as it is called, when it becomes so powerful as to engross the feelings,) is deserving of the attention of the gravest philosopher, as presenting a most powerful stimulus to action, and inciting to the attainment of many qualities which occupy a prominent place in the character of man. It becomes highly interesting to consider the moral influence of this powerful universal principle on human manners : and the wisest will be found to confess, that it has infinitely more effect than some more rational considerations in humanizing the mind of man, and in training him to many useful endowments.

We have endeavoured to show that mental qualifications constitute the charm of love. The lover, therefore, will naturally seek to be distinguished by the qualities which he may think most likely to recommend him to his mistress. And as it is evident that women stand in need of protection, (being greatly inferior to men in bodily strength, and, at certain periods, totally incapable of defending themselves from surrounding dangers, or even of earning subsistence,) the highest recommendation of man in a rude state of society will be personal bravery, or strength. In a more polished state, he will seek to be distinguished by tenderness, generosity, or sympathy ; and in a state of independence and affluence, by those talents and attainments which secure an influence in society. Thus, in every state of society, the principle of love has a powerful influence in moulding the manners, and forming the character of men.

The operation of the feeling on the other sex is quite reciprocal. The female naturally studies the qualifications most likely to recommend her to the object of her choice; and if at any time her pursuits should be trifling or useless, we may rest assured that her choice has originated in the frivolity of the men—for it is their taste, in every instance, which decides the nature and character of female accomplishments. The woman who wishes to please will not think it necessary that her qualifications should exactly resemble those of the man whom she loves. His strength, and courage, and energy, are required as compensations for her weakness; and, therefore, though she should be deficient in these respects, she will not be the less endeared to the man who glories in being called her protector, and who, without any feelings of selfishness, is glad to be possessed of qualities of which she is destitute, that he may the more decidedly prove the extent of his love.

It is by no means necessary, then, that the pursuits of the man and of the woman should be similar, in order to secure mutual regard. They must indeed be actuated by the same grand moral feelings; there must be the same regard to truth, honour, and principle—the same anxious desire to promote each other's comfort; and after this, it matters not how dissimilar their occupations may be. They will rather injure their interests by attempting an approximation in any other respect: and Hercules, with the distaff of Omphale in his hand, is not more ridiculous, and out of character, than the virago, who affects the manners and pursuits appropriate to men. *Quæ fugit a sexu, vires amat.*

Nothing surely is better calculated to promote the general improvement of the species than that principle of love which leads the two sexes to desire and consult the happiness of each other. In the rudest state of society it has its influence. In such a state, indeed, woman is comparatively disregarded: her weakness and dependence render her completely subservient, and make her the degraded drudge of her rough and unpolished yoke-mate. In a state of ease, comfort, and affluence, woman becomes an object of greater consequence, but chiefly as an instrument of pleasure; she then studies the accomplishments which minister to luxury, and, perhaps, acquires considerable influence in society. But she is still in a state of moral degradation; and her beauty and accomplishments are valued by her lord as he values his plate, his equipage, and his furniture; that is, merely as the means of feeding his vanity and promoting his pleasure.

It is in the Christian system alone that woman assumes her true rank in society: for whilst it unfolds the virtues which confer the highest lustre on human nature, it shows that woman is equally susceptible of them with man, or rather, that her nature appears better adapted than that of man for the reception of them. Her feelings harmonize more readily with the mild and benevolent spirit of this religion: and human excellence being shown to consist in the cultivation of virtuous and pious affections, the female who is distinguished by these qualifications may justly aspire to the highest estimation in Christian society; and being, equally with man, the sharer of immortal hopes, she is entitled to the same consideration in the ordinary relations of life.

From what has been said, we think it will evidently appear, that our duty as moral agents may be inferred from the constitution of our nature, and the relations in which we are placed. We may say, with safety, that, to a certain extent, nature points out the line of duty: for we have seen that our appetites, desires, affections, &c. point most distinctly to certain ends, the attainment of which is considered necessary for happiness. But whilst our natural feelings impel us infallibly and irresistibly to desire certain gratifications, they do not point out, with precision, the means by which the end may be attained. These means are learnt by instruction, example, experience, and reason; and after the mind is thus informed, it perceives that the means of obtaining the enjoyments which we desire, though varied, are yet perfectly defined, and that we cannot neglect or abuse them without compromising our own happiness.

We may perceive, then, that the author of our nature has fenced in the path of virtue by numberless safeguards and securities, and which way soever we turn ourselves, we will find monitors of duty, and restraints imposed on vicious indulgence. Yet, with all these advantages, we need not be surprised at the struggles which are so frequently felt between inclination and duty. Such struggles are absolutely unavoidable, for the appetite is blind and indiscriminating; it may impel us to desire what we have no right to aspire to, and which cannot be ours without violating the rights of another. To feel hunger, and desire food, is perfectly natural, and, therefore, cannot be wrong: but it is contrary to justice to gratify this desire at the expense of another. To desire a beautiful woman may be equally natural, but it is wrong to seek the gratification of this desire, if she is already become the property of another. In short, our appetites, passions, and desires, require to be corrected by a consideration of the relations in which we stand to God and to society; and it is a considerable time before these are so distinctly perceived, as to operate surely and expeditiously in regulating the conduct.

Man's moral character results chiefly from his social connections, and these are not adventitious or fortuitously formed. Our analysis of some of the prominent feelings and circumstances of human nature had for its object to show that society, in its various forms and modifications, necessarily results from them; that man is made for social relations, and is gradually trained to discharge the duties required in them, by the moral and intellectual perceptions arising from the constitution of his nature.

Above all, the sense of religion, arising naturally at least, if not necessarily, out of the circumstances and constitution of man, tends to strengthen the power of moral obligation, and to afford an intelligible and universally applicable rule of duty. That it is absolutely necessary appears from this, that no nation has ever been able to do without it; and in every state of society religion has always been assumed as the sanction of morals. That it is so, must be admitted on every rational system of morals; for if there is a God who created all things, and established those laws which we feel ourselves bound to obey, we must evidently consider his will as the sovereign rule by which we ought to regulate our conduct. And if we set such considerations aside, we confess that we cannot perceive, by any powers of reason that we possess, any principle that will make a man forego evident advantages, and submit to serious privations, merely from a sense of duty: and we are more and more convinced that the sense of duty is an unintelligible phrase, or a principle without foundation, unless it be resolved into obedience to the divine law. A sense of interest may make a man avoid certain vices, such as gluttony, intemperance, and the like; but to discharge the relative duties, *a man must love his neighbour as himself;* and we know nothing that can produce this feeling but the conviction that God is the common father, governor, and judge of all.

The moral duties are alike binding on all, and no rank or condition can claim exemption from laws which, being founded on the nature of man, and the will of God, must necessarily be of universal obligation. The circumstances of individuals, however, are extremely various, and almost every man, from his particular situation and relations in society, will be called more frequently to the exercise of some moral duties than others. For these he acquires a fondness, and often displays a peculiar proneness to the performance of them. This is said to be the effect of *habit*, a quality which, whilst it gives additional security and facility to virtue, is not without some tendencies of an opposite character, against which we would do well to be on our guard.

The man who has been trained by habit to the exercise of a particular virtue, is very apt to view it with overweening fondness; and to be harsh and uncharitable in judging of others who do not show the same readiness and facility in the performance of it. The man who is distinguished by any virtue not exactly in the common line of practice, is always sure of an ample share of admiration. We think him something above the ordinary level of mortals, because he seems to do with ease and pleasure what would cost others much difficulty and pain to accomplish.

If the estimation of the world, in this respect, be not altogether correct, it is at least salutary in its influence, and we are more anxious to prevent undue elation in those who are thus distinguished, than to teach men to withhold the mead of praise from any thing that bears the appearance of virtue. In a rigid estimation of the subject, however, a man cannot reckon himself entitled to very high praise for the performance of duties to which he has been trained by a long course of discipline, or by powerful associations.

Dr. Reid has assigned some mysterious influence to *habit*, and has exalted it into an original principle of our nature. "It appears evident," says he, "that as, without instinct, the infant could not live to become a man, so, without habit, man would remain an infant through life, and would be as helpless, as unhandy, as speechless, and as much a child in understanding at threescore, as at three." He afterwards observes, "no man can show a reason why our doing a thing frequently should produce either facility or inclination to do it."

This is certainly putting *habit* out of its place, and making it usurp the province of a more important principle. How is it possible for this ingenious author to make out his position, that, without habit, a man would be as much a child in understanding at threescore as at three? Would not the memory retain the impressions which it had received, the knowledge which it had gained, and the facts which had passed in review before it, without any dependence on the power of habit? And, as we think habit not absolutely indispensable for the acquisition of knowledge, neither do we think that its influence over the human mind is absolutely unaccountable; at least, we think it may easily be referred to an ulterior principle.

In fact, we consider *habit* merely as one of the ordinary phenomena connected with memory and the association of ideas; and on this principle we think its power may easily be accounted for. Whatever has been once before the mind, will find a readier admission when presented a second time; for this plain reason, that it was at first a stranger, but is now recognized as an acquaintance. We might have had some difficulty at first, in understanding it, and it might have cost us a good deal of trouble to discover all its bearings and tendencies; but these difficulties being once removed, never recur; and the fact, or the feeling, or whatever it may be called, being treasured up in the memory, is added to the general stock of knowledge, and becomes, as it were, a new point from which we start in search of ulterior improvement.

But the recurrence of an idea or practice, however frequent, does not necessarily constitute habit. Though we wash our face every morning, or, every morning say our prayers, this is not habit. It is a regular custom, founded on expediency or reason. Neither do we apply the name of *habit* to any of those practices which result from the general constitution of our nature, and are observed by all mankind. We do not say that a man has a habit of taking his breakfast, or dinner, though he does so every day of his life, and has a most decided inclination to the practice. By a habit of eating, we would understand gluttony; as a habit of drinking always implies drunkenness. A man may have a habit of sleeping in his chair after dinner: we never talk of the regular repose of sleep as a habit. Perhaps there is as much of habit in the art of walking as in most things; yet, walking appears so natural, that we never consider it as a habit; but if a man limps without being lame, or slouches, or swaggers in his walk, we say he has acquired habits.

It is evident, then, that we apply the term *habits* to certain practices a little out of the ordinary way, when they obtain a very prominent influence; or to natural practices when carried to habitual excess.—Our moral habits may be explained in the same way. Particular circumstances give more importance in our imagination to one duty than to another. It has, for instance, been particularly enforced by the friend whom we admire; it has been recommended by some very interesting concomitants, or by some powerful considerations of public or private advantage: from these, and similar circumstances, it appears of paramount importance; and in our situation it may, in fact, be so; but we ought not to denounce, as deficient in moral sensibility, those who do not view it with the same rapturous feelings.

All prejudices are *habits* arising out of contracted education, illiberal society, or the example of those who have more influence than sense. All prejudices have a certain degree of moral obliquity attached to them: but, as the defect originates chiefly in the understanding, they may be called *bad intellectual habits*. We do not, in general, view such habits with much moral disapprobation. We are rather amused in tracing their origin; and regard them as the subject of ridicule, rather than of rigid censure. They have, however, a very extensive, and very pernicious influence on the happiness both of individuals and of society, as they obviously impair general benevolence, and obstruct general improvement.

To love the country in which we are born better than any other is not a prejudice: it is a natural, irresistible feeling: and the man who is a stranger to it, must be unacquainted with all the finer sensibilities of our nature. It is impossible to reflect on the scenes with which our recollections of youthful happiness are inseparably associated, without the most decided partiality: it is impossible to think of the place which contains the graves of our fathers, and of the companions of our early days, without feelings of the deepest interest: and a general predilection for our native country must arise in every well regulated mind, from a recollection of the social, civil, and religious ties which have so intimately connected our hearts with the country and community in which we have been brought up. Such feelings as these are not prejudices: for they arise out of natural and unavoidable associations; and there is a defect in the heart of every man who is a stranger to them. But if love to our country and connections leads us to despise other communities, or to hate and dislike those who differ from us in political institutions, in civil customs, or in national manners; in that case, we are under the dominion of the most narrow and hurtful prejudices, and will never be able to exhibit a single feature of general philanthropy, or of genuine christian spirit.

Prejudices in the case of certain contracted minds, and limited understandings, may be useful. They are a sort of substitute for steady principles; and we should be afraid that, were a weak man to renounce his prejudices, he might never find any principles so likely to secure consistency of conduct. On this ground, we are not displeased sometimes to see an obstinate man resisting enlargement of understanding, for he might lose what he would never be able to replace; and his mind might be set afloat without a single light to direct him. We have seen melancholy exemplifications of these observations in the case of many who have been trained up under the *prejudices* of religious education; we say prejudices, for their impressions never rose to the rank of rational principles.

When once they have been laughed out of that veneration which they had been accustomed to entertain for sacred subjects, they become the most disgusting profligates; and, by their nauseous licentiousness, rather do good than harm, to the cause which they mean to injure.

But when we talk of the good effects of any prejudice, we must be understood to speak only of those prejudices which lean to virtue's side. We have very little fault to find with that prejudice which makes a mother believe her own child the finest that ever was born; but there are few prejudices so harmless as this; they generally incline with preponderating bias to the wrong side; and often present insuperable obstacles to the dissemination of correct and enlightened principles. Prejudice is, in many cases, more dangerous than vice; a man can never have the effrontery to vindicate the latter; and however much he may be attached to it, he is generally ashamed to avow it. But the case is wholly different when a man is under the dominion of prejudice; he then glories in his delusion, and is ready to become a martyr to his error.

If what we have said on the subject of *habit* be correct, we ought to reckon all our vices *habits;* our virtues ought not to be accounted so, in our view of the foundation of morals, except when particular circumstances have given unusual prominence to some particular branch of a general duty.*

Few of the duties of life are indeed so obvious as to spring up spontaneously in the human mind; most of them are the result of experience, instruction, or example; and so far they may be accounted habits; as we often understand by that term all acquired qualities. But the general habits of right conduct, like the habits of speaking or walking, are so familiar to the generality of mankind, that we consider them as natural results; and, indeed, they may with propriety be reckoned so; for the leading truths of morality, though some of them may not be palpable at first view, become more obvious every time they are presented to the mind; it sees their bearings and connections more clearly, and perceives them to be enforced by a thousand analogous circumstances and events in the general economy of providence. They then become axioms, instead of corollaries; and that which was originally the result of painful study, and patient investigation, assumes the place of a first principle.

But vice is always contrary to right reason, and to the natural order of things; it is persisted in to the obvious detriment of our best interests; and it is only in consequence of a certain obliquity, introduced by habit into the physical and moral constitution of man, that it is enabled to hold its ground in the face of so many discouragements and dissuasives. Bad habits, by long indulgence, become almost irresistible; the man who has been accustomed to the stimulus of artificial excitement, becomes languid when it is withheld, and would as soon be deprived of meat and drink, as denied the gratification of his acquired appetites. The immediate consequence of excess is langour; a useful lesson to prevent repetition of the same offence against nature. But mankind have discovered artificial stimulants to overcome constitutional depression; and these will be most readily resorted to in time of need; where they are found to answer the purpose, reason has little chance in arguing against them; they have two most conclusive recommendations in their favour; they pre-

* We have here the authority of Aristotle against us. He says that virtue does not properly exist till it becomes the usual habit and disposition of the mind. "Thus the actinn which proceeds from an occasional fit of generosity is undoubtedly a generous action, but the man who performs it is not necessarily a generous person, because it may be the single action of the kind which he ever performed. The motive and disposition of heart, from which this action was performed, may have been quite just and proper: but as this happy mood seems to have been the effect rather of accidental humour than of any thing steady or permanent in the character, it can reflect no great honour on the performer. When we denominate a character generous or charitable, or virtuous in any respect, we mean to signify that the disposition expressed by each of those appellations is the usual and customary disposition of the person. But single actions of any kind, how proper and suitable soever, are of little consequence to show that this is the case. If a single action was sufficient to stamp the character of any virtue upon the person who performed it, the most worthless of mankind might lay claim to all the virtues; since there is no man who has not, upon some occasions, acted with prudence, justice, temperance and fortitude. But though single actinns, how laudable soever, reflect very little praise on the person who performs them, a single vicious action, performed by one whose conduct is usually very regular, greatly diminishes, and sometimes destroys altogether our opinion of his virtue. A single action of this kind sufficiently shows that his habits are not perfect, and that he is less to be depended upon, than, from the usual train of his behaviour, we might have been apt to imagine." Smith's *Review of Systems of Moral Philosophy*.

sent a remedy for present uneasiness, and they are much more palatable than lessons of self-denial, the only cure for the moral maladies of the human mind.

Hence we every day see attempts to reconcile luxury with health, and excess with enjoyment; and every such attempt has a tendency to perpetuate and strengthen the evil, and to render emancipation more hopeless. The son of Dion, who had been corrupted by Dionysius, chose to put an end to his own existence, rather than submit to the restraints which the wisdom of his father attempted to impose; and such facts are perfectly familiar to our observation, for we daily see men falling the voluntary victims of their vices, in spite of the most powerful motives and inducements to reformation of conduct.

It has often been observed, that bad habits are more steady and consistent in their operation than good ones; and it is not difficult to account for the fact. Our virtues carry us to the very verge of vice; that is to say, the slightest excess either in good or indifferent qualities, constitutes a moral offence; and how readily may even a good man be betrayed by the warmth of his feelings, by the influence of example, or of unexpected temptations! But bad habits never can make any approximation to the confines of virtue; the man who indulges them, has turned his back upon it; and every step that he advances carries him farther from the paths of wisdom.

In every judicious system of moral education, few things are more deserving of attention than the formation of habits. The great object to be aimed at in early culture, is the complete occupation of the mind by some employment which may lay the foundation of useful habits in after life; or, at least, may prevent the formation of such as are wrong. And where bad habits have been acquired, they are not to be conquered by the power of argument or of demonstration; they are to be overcome only through the influence of some counteracting practice, which must be made sufficiently interesting to engage the feelings, and abstract the attention from the hurtful habits which have engrossed it. To effect a reformation in such circumstances, is a work of extreme difficulty; but it ought not to be abandoned in despair. The most pernicious habits have often been acquired from the want of congenial employment; for if a man is either idle or forced to do what he dislikes, he has every chance to seek for pleasure from forbidden gratifications. We should think it advisable to give every young person who is not condemned to manual labour, as many securities as possible against the formation of evil habits; and ample resources are furnished in cultivating the pleasures of taste, or in the departments of the arts, or of elegant accomplishments, or of polite literature, or of scientific research, or of harmless amusement. And we believe it has often happened, that, from injudicious restraints, or from the mind being forced into an unnatural channel, the worst consequences have been produced; and the young have been led to seek from vice, that pleasure which might have been found more pure and ample in congenial occupations, or in innocent recreations. We are for diminishing none of the natural resources of human enjoyment; we would recommend them, not only as means of happiness, but as securities for virtue; and if vice is excluded, we shall not be much disposed to find fault with human employments. With this reservation, we would adopt the sentiment of Hesiod, even in the sense in which Socrates's accusers charged him with using it.

Εργον δ'ουδεν ονειδος, αεργειη δε τ' ονειδος.

On the Origin of Evil.

It has often been asked, how there should be so much sin and suffering, or so much vice and misery, in a world created and governed by a God of infinite wisdom and goodness. We do not know that a satisfactory answer has ever been given to this most difficult question; and in agitating the subject at present, we are far from entertaining the hope that we shall be able fully to resolve this *nodus* in the divine economy. The question, however, in one form or another, is indispensable in all discussions on morals: and, though much must necessarily remain unexplained, from the present imperfection of our faculties, we do not despair of removing the difficulty at least some steps farther back, or perhaps of carrying it to the point where acquiescence in the inscrutable will of heaven must put an end to our researches.

The Manichæan notion of two eternal, independent principles, the one good, and the other evil, was very early and extensively received in the East. According to this notion, there was a continual contest between these two principles, and their power was so equally balanced that neither of them could obtain a decided superiority: hence resulted that mixed state of vice and virtue, misery and happiness, so observable in the history of the world, and particularly in the life of man. They must have had very little philosophical observation who could rest satisfied with this clumsy hypothesis; for it is perfectly apparent, that all the physical evils at least (and these were the evils chiefly regarded in this scheme,) are not only reconcileable with the perfections of a wise and good Being, but are absolute indications of his wisdom and goodness in the present state of man.

A more modern hypothesis represents the existence of evil as necessarily arising out of the intractableness and imperfection of matter; from which qualities, some degree of imperfection and evil must be attached to every created thing.* This is intended as a vindication of the Creator: but even granting the premises, it does not answer the purpose; unless it could at the same time be shown, that God was under the necessity of acting, and of calling the world, as we now find it, into existence. For if the Deity had free-will and prescience, it would still remain to be shown, why he gave birth to creation, which must necessarily issue in evil and misery.

The only satisfactory answer to this is, that the evils we deplore are productive of good on the whole, and are essential to the moral discipline of man.

Pope, in attempting to vindicate the ways of God to man, has introduced a very gratuitous and inartificial

* Respondendum est, nihil quidem perfectionis et realitatis pure positivæ esse in creaturis earumque actibus bonis malisque, quod non Deo debeatur; sed imperfectionem actus in privatione consistere, et oriri ex originali limitatione creaturarum, quam jam tum in statu puræ possibilitatis (id est, in regione veritatum æternarum seu ideis divino intellectui obversantibus) habent ex essentia sua: nam quod limitatione careret, non creatura, sed Deus foret. Limitata autem dicitur creatura, quia limites seu terminos suæ magnitudinis, potentiæ, scientiæ, et cujuscunque perfectionis habet. Ita fundamentum mali est necessarium, sed ortus tamen contingens; id est, necessarium est ut mala sint possibilia, sed contingens est ut mala sint actualia: *non contingens*, autem, per harmoniam rerum, a potentia transit ad actum; ob convenientiam cum optima rerum serie cujus partem facit. *Leibnitz. Causa Dei Asserta*, &c.

hypothesis into his celebrated essay. He takes it for granted, that there is a regular gradation of existence rising through every possible variety, and that, therefore, there must be such a creature as man, and such a world as this.

> Of systems possible, if 'tis confest
> That wisdom infinite must make the best,
> Where all must fall, or not coherent be,
> And all that rises, rise in due degree;
> Then, in the scale of reasoning life, 'tis plain
> There must be somewhere such a rank as man.

This reasoning, if reasoning it can be called, is then confirmed by another hypothesis, in which it is assumed, or insinuated, that our present state of being has a reference to some other sphere, or system, as yet unknown. The reader must not suppose that this has any allusion to the commonly received doctrine of a future state. Nothing could be farther from the mind of the writer: he speaks of some system to whose convenience we are, at this moment, unconsciously subservient. This is evident from what he subjoins to his former reasoning.

> So man, who here seems principal alone,
> Perhaps acts second to some sphere unknown;
> Touches some wheel, or verges to some goal;
> 'Tis but a part we see, and not the whole.

It would be unfair to be very severe on this poetical system of the universe, in which splendid imagery and most beautiful versification make some atonement for the grievous deficiency of logical precision; and which is in fact not worse than a hundred other schemes which have been invented to account for the same thing. It is sufficient to say, that it consists wholly of gratuitous assumptions.

In stating the various theories that have been suggested to account for the origin and existence of evil, we may, without encroaching on the province of theology, be permitted to advert to the most ancient account of this subject; which is professedly not a theory, but a statement of historical facts. The account is, that God created man at first upright; but that he fell from his innocence and happiness by eating of the fruit of a certain tree, of which God had commanded him not to eat. There is no violation of probability or verisimilitude in this account. On the contrary, there are numerous memorials in the traditional histories of all nations, which bear a striking resemblance to this statement. The Grecian account approaches nearest to that of the sacred record. It celebrates the innocence and happiness of the golden age; and tells us that this desirable state of things was destroyed by the theft of Prometheus, who stole fire from heaven; and that the gods, to revenge his sacrilege, sent forth hosts of diseases and crimes to desolate the earth.

The coincidence between this account and that contained in Scripture, is too striking to be accidental. The offence and the punishment bear such a resemblance, that both accounts must evidently refer to the same event; and we would naturally assign the superiority, in point of authenticity, to the account which we know to be the most ancient. We do not, however, positively affirm, that the various accounts of the original innocence and fall of man, so widely disseminated throughout the world, have all been immediately derived from the Scripture history. We would rather suppose that the knowledge of these interesting facts was universally diffused; that it remained uncorrupted among the Jews, by being so early embodied in the record of their history and laws; whilst among other nations, being left to float down the uncertain channel of tradition, it assumed those various appearances which have so much obscured and disguised the truth.

The features of probability which distinguish the Scripture account, are, first, that God prescribed to man a test of obedience, in his state of innocence; for without such a test he could not have been a moral and accountable being: he could have had no choice between good and evil, and therefore could not have been a proper object either of punishment or reward. And, secondly, the test prescribed being of a positive and arbitrary kind, was perfectly adapted to the singular circumstances in which man was placed on his creation, in which, as far as we can perceive, he could only sin against an arbitrary statute.

But the difficulty lies not so much in ascertaining the manner in which evil was introduced, as in explaining the reason why it was permitted. Here we may observe, that evil could not have been absolutely prevented, without destroying the character of man, as a moral agent. The few intimations contained in Scripture, respecting the condition of the Angels, are in conformity with this idea. They also were made capable of sinning, in consequence of which some of them fell; whilst the rest, who withstood the trial, completed, in all probability, their probation by that resistance, and are now exempted from the possibility of falling; as the souls of the just shall be, when removed from this state of discipline into the blessedness of heaven. So far, then, our reason compels us to vindicate the Almighty for having made man

> "Sufficient to have stood, though free to fall."

Another ground of vindication is presented to us, when we consider that even the evils which are in the world, are productive of good on the whole. With regard to temporal or physical evils, this is undoubted. The human character is improved by suffering; and the evils which we most grievously deplore, if borne with fortitude, never fail to improve our natures, to increase our knowledge, and exalt our virtue. The havoc and devastation of war correct the licentiousness and effeminacy which result from peace; and difficulties and hardships give a vigour to the character, and an enlargement to the understanding, which never could have been acquired in the midst of ease and soft indulgence.

Even the mutual depredations of the lower animals which prey on each other, though we cannot suppose them productive of any thing like moral improvement, yet display a thousand resources provided by their Creator for their security and comfort; and in this way furnish to rational observers many striking proofs of the goodness and provident care of the Almighty. Besides, the very havoc which is made by mutual slaughter, increases the number of *genera* and *species*; and in consequence of the different tribes of animals preying on each other, provision is made for an infinitely greater variety and number than could have existed, had they all lived on one kind of food.

In short, the whole system of external nature seems completely adapted to man, as a creature born in ignorance, and continually liable to sin; and we might have inferred, though we had had no information on the subject, that the constitution of nature, or the system of the universe, was changed, when man forfeited his innocence, and became subject to sin; for as it exists at present it could have answered no purpose, in the primeval state of purity, but to impair human happiness. The Scripture account corresponds with this suggestion, or rather, perhaps, the suggestion itself has arisen out of the Scripture history; for we do not pretend to belong to that school of philosophy which would keep the mind completely uninfluenced by such considerations; and we have been taught from our infancy to believe, that the earth was cursed with sterility on account of man's transgression; and that the elements and system of nature were henceforth charged with hostility against the life and happiness of man.

At the same time, these evils serve both as punishments and correctives; their evident design being to obviate the evil tendency of our appetites, passions and affections; and whatever uneasiness they may cause, man, as his nature is now constituted, is undoubtedly happier than he would be without them.

But we do not pretend wholly to remove the difficulties connected with this question, when we endeavour to show that the outward arrangements of Providence are adapted with infinite wisdom to the present condition and circumstances of man. For the question is, How the condition of man came to be as we now find it; and why evil and suffering are permitted to find a place among the works of a good and merciful God? We will perhaps be fully as near our purpose to say at once, "Such is the will of Him who orders all things well and wisely." But men are not disposed to rest here; and they have anxiously laboured to separate the existence of evil from the ordinations of Heaven, affirming that though God *foresaw* the introduction of evil, yet he neither willed nor appointed it. This, however, will perhaps not appear to many quite satisfactory; for, as every thing depends on the Almighty, it may be said that his *prescience*, or knowledge of what is to happen, must have the same effect as an absolute decree.

There is one way of getting rid of this difficulty; but we fear it will not mend the matter much. It is affirmed, for instance, that *prescience* actually does not belong to God, and that any idea, implying either *Post* or *Præ*, must be totally inapplicable to a Being who fills eternity with his presence, with whom a thousand years are as one day, and one day as a thousand years. This is, no doubt, true; but if it is available for any thing, it is to silence, rather than to satisfy our reason, and to show us our utter incompetency to comprehend the things of God. It is of no use as an explanation, unless it could be shown that the actions of men are altogether independent on God, and that he could not prevent them from being what they are: but this would be vindicating his justice at the expense of his omnipotence, and exalting his mercy by denying his power.

We must not suppose that the Almighty has been directed in his determinations or decrees by any thing resembling the fate which the ancients represented as binding gods and men: we must conceive him to be perfectly free in his determinations and his actions; and though evil is permitted, we have reason to conclude that it could not be prevented, without the obstruction of a greater good. Hence the observation of Augustine, quoted with approbation by Thomas Aquinas and Leibnitz, *Deum permittere quædam mala fieri, ne multa bona impediantur.* The latter author observes, that every thing whose contrary implies a contradiction has a necessary existence; but every thing that might be otherwise than it is, though determined to be what it is, for sufficient and infallible reasons, is contingent. "Cela posé, l'on voit comment nous pouvons dire, avec plusieurs philosophes et theologiens célébrés, que la substance qui pense est portée à sa résolution par la représentation prévalente du bien ou du mal, et cela *certainement et infailliblement*, mais non pas nécessairement: c'est à dire, par des raisons qui l'inclinent sans la nécessiter. C'est pourquoi *les futurs contingens*, prévus et en eux-mêmes et par leur raisons, demeurent contingens; et Dieu a été porté infailliblement, par sa sagesse et par sa bonté, à créer le monde par sa puissance, et à lui donner la meilleure forme possible; mais il n'y étoit point porté nécessairement; et le tout s'est passé sans aucune diminution de sa liberté parfaite et souveraine. Et sans considération que nous venons de faire, je ne sais s'il seroit aisé to resoudre le nœud Gordien de la contingence et de la liberté." *Rémarques sur le Livre de l'Orig. du Mal.* And with regard to the existence of evil, under the administration of a Being powerful, wise and good, it is to be observed, that there is a wide difference between causing or appointing evil, and merely permitting it. This subject is illustrated by Jonathan Edwards by a striking analogy. "There is a vast difference," says he, "between the sun's being the *cause* of the lightsomeness and warmth of the atmosphere and brightness of gold and diamonds, by its presence and positive influence, and its being the *occasion* of darkness and frost in the night, by its motion, whereby it descends below the horizon." "If the sun were the proper *cause* of cold and darkness, it would be the *fountain* of these things, as it is the fountain of light and heat; and then something might be argued from the nature of cold and darkness to a likeness of nature in the sun; and it might be justly inferred, that the sun itself is dark and cold, and that his beams are black and frosty. But, from its being the cause no otherwise than by its departure, no such thing can be inferred, but the contrary: it may justly be argued, that the sun is a bright and hot body, if cold and darkness are found to be the consequence of its withdrawment; and the more constantly and necessarily these effects are connected with and confined to its absence, the more strongly does it argue the sun to be the fountain of light and heat. So, inasmuch as sin is not the fruit of any positive agency or influence of the Most High, but, on the contrary, arises from the withholding of his action and energy, and, under certain circumstances, necessarily follows on the want of his influence; this is no argument that he is sinful, or his operation evil, but, on the contrary, that he and his agency are altogether good and holy, and that he is the fountain of all holiness. It would be strange arguing, indeed, because men never commit sin, but only when God leaves them to themselves, and necessarily sin when he does so, and therefore their sin is not from themselves, but from God, and so that God must be a sinful Being: as strange as it would be to argue, because it is always dark when the sun is gone, and never dark when the sun is present, that therefore all darkness is from the sun, and that his disk and beams must needs be black."

But even the moral evils which are in the world, however destructive they may be to those with whom they originate, are productive of good, on the whole. In a state like the present, where man has to learn almost every thing by experience, instruction, or example, the aberrations of the wicked, and the obvious consequences of their sins, afford a useful lesson, and supply demonstrations of the danger of deviating from the plain path of rectitude, as pointed out by the ordinations of Heaven. Besides, we receive a clearer proof of the superintending providence of God in overruling the disorderly passions of men, and making them subservient to the purposes of his will, than if all went on regularly and smoothly, without a single jarring or discordant principle to disturb the harmony of the universe. Every man has his own centre towards which he would gravitate, or his own right line in which he would move, were he not drawn from it by some superior force which connects him with the general system of society. In short, the intention of the Almighty, both in the natural and moral world, seems to be, to produce regularity and order out of materials which are naturally inert or perverted; and so much of the *discordia semina rerum* is still to be seen, both in the elements of nature and in the constitution of human society, as to bespeak a present Deity to regulate and adjust them.

We have already shown, that the moral qualities of man are improved and exalted by the physical evils which he is called to encounter, and the same effect is produced by the moral evils to which he is exposed. The injuries and provocations of the wicked show the odious nature of the principles by which they are actuated, and produce in our minds a natural dislike of those qualities which offend us; whilst patience, and prudence, and meekness, and forgiveness, are called into exercise, and the mind which improves the lesson is purified, adorned and exalted.

But if any thing farther be wanting, as a compensation for the evils, moral and physical, which are in the world, or as a vindication of the benevolence of the Almighty, we conceive it is abundantly furnished by the promulgation of Christianity, which presents such a view of the divine benevolence and love to the human race, as we could not have formed a conception of, even in a state of paradisaical innocence and happiness. In short, this world, both in its physical and moral aspect, is exactly as the Almighty intended it should be. Why it is as it is, it would be as useless to inquire, as it would be to ask why God has made any thing as it is, or why he has bestowed on man, and the various tribes of animals, the powers and qualities which distinguish them. With regard to animals, we are satisfied with showing, that their faculties are adapted to their circumstances, and consider this as conclusive as to the goodness of God: and why should we not rest satisfied, and adopt the same conclusion, when we perceive that the present state of things is admirably adapted for the improvement of moral beings. Difficulties, indeed, frequently occur; but they are rendered useful for sharpening our faculties, and extending our knowledge, and it is impossible to mention an evil, for which the Almighty has not provided an adequate compensation.

There is no evil which men view with so much horror as death: exempt them but from this, and every other evil will appear tolerable;* yet, in so far as regards the general economy of nature, death cannot be accounted an evil. One generation passes away; but the loss is soon repaired; and the affairs of men go on with renovated vigour and increased knowledge, from the accumulated wisdom and experience of the ages which are past.

Of living things, there is not one that does not ardently desire to enjoy the continued blessing of existence; but it is not more inconsistent with the decrees of heaven than with general happiness and usefulness, that this desire should be indulged to any great extent. With regard to the human race, the near approach of death operates as a friendly monitor, in the case of every individual, to repress the extravagance of ambition, to teach sobriety of mind, and to stimulate to the acquisition of qualities which cannot be affected by the dissolution of the body.

Death, in its moral effects, is not only useful for individual improvement; but that general destruction which overwhelms successively every thing that lives, is, in fact, conducive to the general happiness and improvement of the human race.

Why should the present race of mortals monopolize the blessings of existence? After they have had their share in the business, the enjoyments, or the miseries of life, is it not reasonable that they should be removed from the stage, to give place to others who may taste the same pleasures,† and exhibit the same characteristic features of conduct, though diversified by various shades of improvement, and occasionally of deterioration? In so far as the wisdom and goodness of the Almighty are concerned, these attributes, we may safely affirm, are more conspicuously displayed in his giving life and enjoyment to successive millions of animated beings, than if the blessings of life were confined to the existing generation of men and animals.

As things are at present ordered by the wisdom of the Almighty, countless myriads of living creatures appear in succession to taste the blessings of existence, or to celebrate their Maker's praise, either by the voice of intelligence, or by the mute, yet expressive testimony of their actions. Nay, the dispensation of death, which we so generally deplore, furnishes scope for the enjoyment of some of the purest pleasures which man can experience here below. For the constant waste of the species is supplied by children born in our own image, in whose happiness we are deeply interested, whom we view as our representatives to other generations, and in whom our lives are so bound up, that death can scarcely appear even a natural evil, when we have transmitted, as it were, our existence and our comforts to others, whom we love as our own souls.

Thus, then, viewing that dispensation of the Almighty which has doomed all mankind to death, merely as a measure of the divine government, and unconnected

* The inordinate love of life is strongly pictured in the lines which represent the feelings of the effeminate Mæcenas:

Debilem facito manu,
Debilem pede, coxa,
Tuber adstrue gibberum,
Lubricos quate dentes;
Vita dum superest, bene est;
Hanc mihi, vel acuta
Si sedeam cruce, sustine.

† Lusisti satis, edisti satis, atque bibisti,
Tempus discedere.

with our particular feelings, it cannot but appear perfectly consistent with propriety and wisdom. It is useful for bringing a change of actors on the stage of human life, that old vices may be forgotten, that inveterate habits of wickedness may be destroyed, and that new improvements may be introduced in morals, politics, and religion; or that a fresh generation may admire and revere the fabric reared by the wisdom of their forefathers, or bequeathed to them by the bounty of heaven.

Could we view death as unconcerned spectators, we have little doubt that the conclusions which we have stated above, would appear convincing. But we cannot regard this grand consummation with feelings of indifference: it appears as a formidable evil and a terrible catastrophe to every one who values the blessings of life, or prizes the endearments of social intercourse; for all these must be surrendered; and to remain entirely unaffected under such prospects, would bespeak more insensibility than sound philosophy.

But this overpowering evil has a compensation in the hopes of immortality, which the light of nature taught the more virtuous among the heathen to cherish, and which Christianity has unfolded with the most commanding influence. The doctrine of the soul's immortality is second only to the notions which we entertain respecting the attributes of God, in its influence on the conduct of moral agents. It is made subsidiary to the laws in every state; and we have never known any nation under a regularly organized system of laws destitute of a belief of a future state. Warburton affirms, that the Jewish theocracy is an exception; and because the rewards of virtue, and the punishment of vice, under the Mosaic economy, are all of a visible and temporal kind, he infers that there must have been an immediate divine interference to encourage the righteous, and keep in awe the wicked. The argument may not hold in the full extent to which he carries it; but we have always thought it entitled to more attention than it generally receives, and to be deserving of other praise besides that of ingenuity and profound learning.

We conclude our speculations on the existence of evil, in the words of an American writer,* whose views on this subject coincide with our own. "It is difficult to handle the *necessity of evil* in such a manner as not to stumble such as are not above being alarmed at propositions which have an uncommon sound. But if philosophers will but reflect calmly on the matter, they will find, that, consistently with the unlimited power of the Supreme Cause, it may be said, that, in the best ordered system, *evils* must have a place." "If the Author and Governor of all things be infinitely perfect, then whatever is, is right. Of all possible systems, he hath chosen the *best;* and consequently there is *no absolute evil* in the universe. This being the case, all the seeming imperfections or evils in it, are such only in a partial view; and, with respect to the *whole* system, they are *goods*." "For if there be any evil in the system that is not good with respect to the *whole*, then is the *whole* not good, but evil, or at best very imperfect; and an author must be as his workmanship is; as is the effect, such is the cause. But the solution of this difficulty is at hand, that there is no evil in the universe. What! Are there no pains, no imperfections? Is there no misery, no vice, in the world? Or are not these evils? Evils indeed they are; that is, those of one sort are hurtful, and those of the other sort are equally hurtful and abominable; but they are not evil or mischievous with respect to the *whole*."

It forms a natural part in every regular discussion on moral science, to examine the foundation on which the important doctrine of the soul's immortality rests, with a view to ascertain its influence on human conduct.

With regard to the origin of this doctrine, it seems to stand much on the same footing as our belief in the being of a God; and the two together constitute the whole of natural theology. We suspect, however, that the doctrine of the soul's immortality is, in most cases, where it has not been expressly revealed, the result of traditional information, rather than the offspring of reason. It is true, indeed, that when once the doctrine is known, a thousand arguments may be adduced, both from the nature of God, and the moral constitution of man, to establish and confirm it; but whether the natural reason of man would have discovered it, is a question that cannot possibly be solved, unless we can find a nation cut off from all intercourse of knowledge, both with its contemporaries and predecessors.

Most of the ancient philosophers, with the exception of Epicurus and his followers, believed in the immortality of the soul. But many of them held the doctrine in a sense that rendered it inconsistent with a state of rewards and punishments in a future world; for they conceived the soul to be essentially immortal, as being an emanation from the divine nature, into which they supposed that it was again absorbed, when separated from its earth-born companion. Such an opinion as this necessarily destroyed any influence which the doctrine of immortality could have in repressing vice, or encouraging virtue, or alleviating misfortune; for if the soul is to have no distinct consciousness, and no separate existence after death, it could not be more materially affected even by annihilation; and on these principles we should be forced to subscribe to the opinion of Lucretius, who strenuously endeavours to establish the materiality and mortality of the soul.

> Nam si tantopere est animi mutata potestas,
> Omnis ut actarum exciderit retinentia rerum;
> Non, opinor, id ab letho jam longiter errat.

All the ancient philosophers who held the immortality of the soul, believed also in its pre-existence, or rather in its self-existence and eternity; having an idea that, if it had a beginning, it could not be necessarily immortal. Modern philosophers have been affected by this argument, and have, in consequence, been disposed to give up the idea of the natural immortality of the soul; ascribing its indestructibility to the decree of its Creator, and not to any quality inherent in itself. We certainly are not disposed to affirm, that the soul inherits immortality as an independent attribute. But we have no hesitation in affirming, that we can have no idea, from any thing we observe in the visible world, of the annihilation of any created substance. We see dissolution, separation, or division of parts, or alteration of form and figure; but by no process to which any material substance can be subjected, do we perceive any thing that approaches to annihilation. If a miracle was necessary to call matter into existence, we conceive that a miracle would be no less necessary to produce its annihilation and extinction.

* Turnbull.

On these principles, then, we do not think it quite evident that every thing which is created must be necessarily mortal. We ought rather to infer, that it has received an existence which nothing but a miraculous interference of divine power can destroy. But, whatever may be thought of the natural durability of material substances, it is evident that the soul is not composed of matter, and therefore cannot be affected by any of the accidents which seem to dissolve or to destroy it. The soul is conscious of feeling, thinking, judging, reasoning, qualities which it is not even possible to conceive to belong to matter. All the properties of matter may be reduced to extension, figure, colour, bulk, hardness, softness, and the like, which have no more resemblance to any of the known properties of mind, than a sunbeam has to the earth which it enlightens. Since, then, it is not possible to institute any comparison between the properties of mind and matter, it is evidently illogical and inconclusive, to argue that the soul must fall with our material bodies. The body is corrupted, changed, and disorganized, by the division or dissolution of its parts. This is the only idea that our senses present to us of death. But it is not even possible to conceive that the mind can be subjected to such a process; for it is not composed of parts: it is indivisible and indiscerptible, and cannot be affected by any of the accidents which alter or derange a material and divisible substance.

Another argument for the soul's immortality may be drawn from the faculties with which it is endowed. It is evidently possessed of powers capable of indefinite improvement: we can scarcely form an idea of any limits which can be set to its advancement. This improvement of the soul, however, is scarcely begun in the present world: a man has barely time to look about him, and contemplate the attainments to which he may aspire, when he is cut off in the very commencement of his career of improvement, and prevented from making those advances in virtue and knowledge, of which he feels his nature to be susceptible.

Now, we may reasonably ask, why such extensive capabilities should be given to the soul, if it is to be extinguished before they are evolved? It is a common observation, that God does nothing in vain; that there is nothing superfluous, unnecessary, or redundant, through all the works of nature; that every animal has organs and instincts adapted to its necessities and its uses; and is never furnished with faculties or propensities for which there is no adequate exercise or enjoyment. We may naturally conclude, then, that those faculties in man which enable him to contemplate the divine nature, and to resemble the divine perfections, are intended for a higher sphere of existence, where they will be fully unfolded and fully gratified; which is by no means the case in the present world.

Again: from every idea that we can form of God, we are forced to conclude, that he must be offended with vice, and pleased with virtue; and, of consequence, that the one will be punished, and the other rewarded. This, however, is evidently not done in the present world; for here vice often reigns triumphant, whilst virtue is calumniated and oppressed. We may, therefore, naturally conclude, that there must be a period of retribution, when all these irregularities shall be finally adjusted.

But, in truth, were God actually to punish and reward virtue in the present world, it would not remove one of our doubts and difficulties as to the equity of the divine administration, unless we were possessed of the omniscience of the Sovereign Judge, and knew precisely all the motives by which the actors have been influenced; for in these alone consists the merit and the demerit of their conduct. As such knowledge as this is wisely denied us in the present world, the season of final retribution is properly deferred till the time when the secrets of every heart shall be made known, and the whole universe made to recognise the justice and wisdom of the divine administration.

It is indeed said, that virtue is its own reward, and vice its own punishment, even in the present world; and certainly it cannot be denied, that the man who violates the eternal laws of providence will find himself punished in the very transgression. But a cautious sinner may avoid all these consequences; he may be filled with envy, malignity, dishonesty, and every evil affection; his character may be stained with every shade and degree of moral turpitude in the sight of God, whilst it appears spotless and unsullied in the eyes of men. There is no temporal punishment provided for such guilt as this; even conscience does not necessarily prove an avenger; on the contrary, the wretch may find a kind of fiend-like enjoyment in the gratification of his unhallowed affections. We grant, indeed, that the virtuous may experience much happiness in the approbation of their conscience, even amidst the troubles and calamities of life; but this is only in consequence of a conviction that they are acting according to the eternal rules of rectitude which God has established, and that consequently their conduct must be pleasing to him. The wicked, on the other hand, often experience the greatest torture in the compunction and remorse of their consciences; but this arises solely from the fear of future punishment, which their guilty consciences tell them they have deserved.

Such are some of the arguments which the light of nature furnishes in favour of the soul's immortality; a doctrine which has had a most extensive reception, and a no less extensive influence in every state of human society. The vulgar, who were not misled by philosophical speculations, had distinct views of a state of reward and punishment; and though their creed was, in many respects, very erroneous, and very absurd, we firmly believe that it had more efficacy than all the laws that ever were invented by man, in directing to that line of conduct which was conceived to be agreeable to the will of the gods.

The question of Liberty and Necessity.

The question of *liberty* and *necessity* has always been conceived to be intimately connected with morals; and has had a place in almost all systems of moral science. Yet none has been involved in such perplexity; and on none do the opinions of writers appear so diametrically opposite to each other. We consider this as a sure proof that they do not understand each other's reasoning, or that they affix totally different ideas to the terms in which their propositions are announced; and whilst they are exhausting their ingenuity in demolishing the arguments of their adversaries, they are very often only combating the phantoms which their own imagination has raised. The advocates for *liberty*, on the one hand, charge the opposite doctrine with many tremendous consequences. They represent it as subversive of all moral agency, as breaking down the fences of virtue, and opening the door to immorality and irreligion. And it must be confessed, that Hobbes and others have held the doctrine in such a form as fully to authorize these conclusions. But, on the other hand, Leibnitz and Edwards state the doctrine of necessity in such a way, as to vindicate it from all such charges; and the latter author undertakes to demonstrate, that the opposite scheme infallibly brings along with it all the evil consequences which its advocates have attempted to connect with the doctrine of necessity.

It is evident from this, that there must be some grievous misunderstanding on the one side or the other; for without this, it would be impossible to conceive that men of learning and ingenuity, as the disputants in this controversy generally are, should arrive at such opposite conclusions on the same subject. Whether we shall be able to untie this Gordian knot to the satisfaction of our readers, we think is very doubtful. We shall endeavour, however, to give a fair view of the question, and shall state without reserve our own opinion.

The advocates for liberty are hard pressed by the argument that the will is influenced by the last determination of the understanding, or by previous habits, or by that which appears at the time most desirable. If they admit this, the question is decided; for that liberty which they reckon essential to moral action is destroyed. This is confessed by Archbishop King,* who brings the matter to a very distressing dilemma; for he says, that if the will is influenced by reason, it is not free; and, if it is not thus influenced, it acts irrationally. One would not think it easy to escape from the horns of this dilemma; but this author attempts it by a method almost peculiar to himself; for, with the exception of his very able commentator, we scarcely know any who has adopted it. His scheme is, that "things are not chosen because they are good, but become good because they are chosen."

We would here notice the strange idea that this author, and indeed almost all the advocates for liberty, entertain respecting the nature of human freedom. According to their notion, a perfectly wise and good man, who cannot possibly *will* what is foolish or wicked, is subject to a necessity destructive of virtue and moral responsibility. On the same principle, it might be said that the Supreme Cause cannot be free, because he cannot but do that which is wisest and best. This, as Dr. Clarke observes, is a necessity, not of nature or of fate, but of fitness and wisdom; a necessity consistent with the greatest freedom and most perfect choice; for the only foundation of this necessity is such an unalterable rectitude of will, and perfection of wisdom, as makes it impossible for a wise being to act foolishly. "Though God is a most perfect and free agent, says the same author, yet he cannot but do always what is best and wisest on the whole. The reason is evident; because perfect wisdom and goodness are as steady and certain principles of action, as *necessity* itself; and an infinitely wise and good Being, endued with the most perfect liberty, can no more choose to act in contradiction to wisdom and goodness, than a necessary agent can act contrary to the necessity by which it is acted; it being as great an absurdity and impossibility in choice, for infinite wisdom to choose to act unwisely, or infinite goodness to choose what is not good, as it would be in nature for absolute necessity to fail of producing its necessary effect."

We may apply this subject to human agents in the words of Mr. Locke. "'Tis not a fault, but a perfection of our nature, to desire, will, and act, according to the last result of a fair examination. This is so far from being a restraint or diminution of freedom, that it is the very improvement and benefit of it: it is not an abridgement, it is the end and use of our liberty; and the farther we are removed from such a determination, the nearer we are to misery and slavery. A perfect indifference in the mind, not determinable by its last judgment of the good or evil that is thought to attend its choice, would be so far from being an advantage and excellency of any intellectual nature, that it would be as great an imperfection, as the want of indifferency to act or not to act, till determined by the will, would be an imperfection on the other side. It is as much a perfection, that desire or the power of preferring should be determined by good, as that the power of acting should be determined by the will; and the certainer such determination is, the greater the perfection. Nay, were we determined by any thing but the last result of our own minds, judging of the good or evil of any action, we were not free. The very end of our freedom being, that we might attain the good we choose; and, therefore, every man is brought under a necessity, by his constitution as an intelligent being, to be determined in willing, by his own thought and judgment, what is best for him to do; else he would be under the determination of some other than himself, which is want of liberty. And to deny that a man's will in every determination follows his own judgment, is to say that a man wills and acts for an end he would not have, at the same time that he wills and acts for it. For if he prefers it in his present thoughts before any other, it is plain he then thinks better of it, and would have it before any other; unless he can have, and not have it, will, and not will it, at the same time; a contradiction too manifest to be admitted. If to break loose from the conduct of reason, and to want that restraint of examination and judgment, that keeps us from doing or choosing the worse, be liberty, madmen and fools are the only free men. Yet I think nobody would choose to be mad, for the sake of such liberty, but he that is mad already."

King gives up all idea of vindicating the freedom of the human will on any other principle than that which he has adopted, viz. that things chosen derive their value from the choice of the mind; and we think it may be fairly concluded, that the cause is lost if it has no better support. He complains that the friends of the opposite doctrine deal in subtleties, and in arguments remote from common feeling and common apprehension. But the charge may with justice be retorted on himself, and it may be affirmed, that none has ever advanced such a paradoxical argument on the subject, nor maintained it by such subtle and paradoxical reasoning. It is indeed gratifying to think of the mind's omnipotence, and of its superiority over the circumstances of time, place, and accident; and there can be no doubt, that, with proper regulation, it may be the fabricator of its own happiness. But this is not to be effected by a mere independent fiat of the will, and by the creation of means to secure happiness; but by a judicious application and proper use of those circumstances which are presented in the arrangements of Providence. Before the mind can have that independence on circumstances which this author assigns to it, it would require to be not only omnipotent, but omniscient. It must either be omnipotent, to model events

* Origin of Evil.

by a simple volition, as the Almighty did, when he called all things into existence; or it must be omniscient, that its volitions may not interfere with the established order of nature: but the author claims neither of these attributes for it, when he asserts its independence on nature, judgment, association, and reasoning. All that he claims for it is, that it should be able to discern the things which are possible from those which are impossible, and thus provided, it has its happiness completely in its own power. "That person must be happy," says he, "who can always please himself; but this agent can evidently do so. For since things are supposed to please him, not by any necessity of nature, but by mere election, and there is nothing which can compel him to choose this rather than another; it is plain that the agent endowed with this power may always choose such things as it can enjoy, and refuse, that is, not desire or not choose those things which are impossible to be had. And from hence it appears of how great importance it is, whether that whereby things become agreeable to the appetite, be established by nature, or effected by the agent himself. For if good and evil proceed from nature, and be inherent in objects, so as to render them agreeable or disagreeable antecedent to the election, the happiness of this agent will always depend upon them; and unless the whole series of things be so ordered, that nothing can happen contrary to his appetites, he must fall short of happiness."

Now, though we certainly should be sorry to countenance the doctrine, that a man's happiness is entirely at the mercy of external circumstances; (for there are many *rational* considerations which tend to diminish the influence which adverse circumstances would otherwise exert over our happiness;) yet we affirm, with perfect confidence, that there are pains, trials, and disappointments, which must produce unhappiness, unless they are counteracted by reason, hope, or religion. According to the doctrine which we are combating, a man when placed on the rack ought not to be unhappy; for the mind is altogether independent on such circumstances. But certainly there is no man whose feelings are not paralysed by disease, but must feel pain in such circumstances; and if pain be not an evil, then the ingenious author should have given a different form to his very important, though in many respects very eccentric, Essay on the Origin and Tendency of Evil; and should have endeavoured to show that no such thing as evil exists in the universe.

This holds undoubtedly true with regard to physical evil; for if there be nothing in external circumstances which has a direct tendency to affect our happiness, then it is idle to talk, as the author has done at so great length in the first part of his book, of the physical evils of hunger, disease, death, &c. And Leibnitz has shewn no less clearly, that if the mind choose without a motive, there can be no moral evil; for moral evil consists in a wrong choice, and if there be nothing to direct the choice, how can it be wrong? "Dans le fond, bien loin que ce soit montrer la source du mal moral, c'est vouloir qu'il n'y en ait aucune. Car si la volonté se determine sans qu'il y ait rien, ni dans la personne que choisit. ni dans l'objet qui est choisi, qui puisse porter au choix, il n'y aura aucune cause, ni raison de cette election: et comme le mal moral consiste dans le mauvais choix, c'est avouer, que le mal moral n'a point de source du tout. Ainsi dans les regles de la bonne metaphysique, il fraudroit qu'il n'y eut point de mal moral dans la nature; et aussi par la meme raison, il n'y auroit point de *bien moral* non plus, et toute la moralité seroit detruite." *Remarques sur la Livre de l'Origine du Mal.*

Hume has observed, and there is undoubtedly truth in the observation, that we can trace a general course of human conduct almost with as much certainty as we can trace a general course of nature; that is, we may pronounce that men will act in a certain way in given circumstances with as much confidence, as that trees will grow in a given situation: and he justly considers this determination which the conduct receives from circumstances as subversive of that liberty for which many contend. Yet, unless we can remove this influence of motives, that *indifference* which is reckoned essential to liberty is completely destroyed. And how is it possible to remove this influence? It is directly contrary to the whole scheme of our philosophy to suppose it possible; for we have assumed it as an unquestionable principle, that the general course of nature influences both our moral and intellectual associations: that with regard to intellectual attainments, the mind does little more than methodize the facts, and treasure up the relations presented in the course of nature; and the whole of this article has been conducted on the supposition that our volitions are influenced with infallible certainty, by the circumstances of our nature, and the visible arrangements of providence. The beautiful order which we observe among the works of God is intended to facilitate the acquisition of knowledge, and render the path to the temple of science attractive and delightful; and it is equally intended to influence our volitions and our moral perceptions; for it would be a most extraordinary inconsistency, to affirm that God has formed arrangements for human happiness, and yet that men act at random, without any regard to the manifest will of heaven.

The advocates of liberty contend that the scheme of necessity renders means, exhortations, promises, and threatenings, altogether unavailing. Without stopping to obviate this, at present, we would merely observe, that their own plan must produce this effect in a tenfold degree, for it lies at the foundation of their scheme, that motives do not influence; for if they did, there would be an end of liberty; and if motives do not influence, what is the use of exhortations, promises, or threatenings.

But will any man, whose ideas are unsophisticated by a philosophical or theological system, pretend to say that the mind is not influenced by instinct, education, association, habit, passion, prejudice, &c. &c.? And if if it be thus influenced, there is an end of indifference of choice, and with it of liberty. Law, in his commentary on King's Essay, supports the principle of *indifference* by the following reasoning. "Let a thing appear never so pleasant and agreeable, never so reasonable, fit, and eligible to us, yet there is still a *natural* possibility for us to will the contrary, and consequently the *bare power of willing* is in itself indifferent to either side." There is a fallacy here. In perception, the mind is almost wholly passive, and simply receives the impressions made upon it through the medium of the senses; in volition it is wholly active. Volition does not, like perception, impart any feeling to the mind; it is merely the organ or instrument, by means of which the mind manifests its determinations; and the will never can be indifferent when it is in action; when it is not in action, it is in nonentity. And with regard to what this author says, that there is a *natural possibility* for the mind to form a choice, in opposition to every perceived advantage, and every preponderating circumstance, the fact is admitted by every enlightened *necessitarian*, and he only wishes this author, and all who favour his sentiments, to keep in mind the distinction between *physical* and *moral* impossibility. These are generally, perhaps industriously, confounded by the advocates for liberty, with a view to bring odium on the opposite doctrine; and they represent the scheme of necessity as resembling a tyrant, who should bind a man to the ground with fetters, and then punish him because he does not, in these circumstances, obey the command to rise and walk.

There cannot be a grosser misrepresentation of the doctrine. In the supposed case the mind is free, but the body is subject to physical restraints, which prevent volition from issuing in action. But in all moral delinquencies, the mind is indisposed or enslaved; and the inability to act proceeds only from its own want of inclination. No restraint whatever is laid on the mind; it goes wrong, not in consequence of any perceived constraint, but merely by yielding to the bias of its own inclinations. However strong any temptation may be, no man can say that it is *absolutely* irresistable; were it so, it would amount to *physical impossibility*, and would exempt from all blame, and from all moral impossibility. But the man who yields to temptation is only subject to a *moral inability*, induced by bad habits, which he has no inclination to resist. In short, he *wills* to go wrong, and with his own full and perfect consent runs headlong into vice or folly. Physical restraint is always palpable; moral restraint cannot be so: for the evil rests in the will itself, or, to speak more properly, in the mind which actuates the will: and it is not sensible either of restriction or constraint whilst it is following the decided bent of its inclinations.

Would it not, then, be in the highest degree absurd, for any man to complain that his liberty is impaired, when he is both *willing* and *acting* as he pleases. And this species of liberty, and it is the only one of which we have any conception, is left entire by the advocates for necessity. But the liberty of indifference, so much contended for, is incomprehensible. If it consists in acting without motives, there can be no more merit or demerit in the actions than if they proceeded from blind fate or accident; or if it consist in the power of acting contrary to motives, it cannot surely be thought a very enviable prerogative to have the privilege of acting in opposition to reason.

That we are influenced by motives is certain: the person who despises them is not entitled to the appellation of a rational being: and that God has intended that we should be influenced in a particular way, is no less certain; for our instincts, appetites, and passions have distinct and definite objects, to which they are adapted; and the whole course of nature and providence co-operates with them in directing our conduct to particular ends. So far, then, we may say, without hesitation, that the liberty of indifference is destroyed by the decree of heaven; and that God himself, by the arrangements of his providence, has controlled the volitions and the conduct of men.

Shall we then ascribe to God the sins of men, and the various aberrations of human conduct? This consequence would be unavoidable, were men swayed by a *physical* necessity, and did their reason tell them that it is *absolutely* impossible to resist the suggestions to evil. But the case is directly the reverse. Instead of being constrained to do wrong, by a *physical* necessity, it is quite apparent that God has done every thing, as far as is consistent with the moral responsibility of man, to cast the balance on the other side, and to constrain human beings to walk in the paths of virtue. The miserable consequences of transgression, conscience, reason, sympathy, together with every original or accessary feeling of our nature, concur in lending their influence to strengthen the obligations of moral duty. They, in fact, do all *but absolutely compel us*, to make us virtuous and happy. And so far from feeling ourselves, in any instance, constrained to do evil, the compunctions of conscience are sharpened by the conviction, that we have acted in opposition to the most obvious inducements to virtue. Whatever necessity, then, there is arising out of the appointments of heaven, it is all on the side of virtue; and the self-condemnation of the offender arises from the consciousness of having resisted it. Every thing presented in the economy of the Divine government is either positively good, or capable of being turned to good. Riches, power, and honours are designed by heaven to be the rewards of industry, bravery, or virtue: and no man can say that God has misled him, if he aspires to the reward by means which are not consecrated by the appointment of heaven; and he has no reason to complain, if he finds misery and disgrace, instead of the pleasures which he anticipates. He cannot say that he mistook the means; it is evident that he understood them perfectly, by exhibiting the semblance of those virtues which God delights to honour: but he expects to reach the end by a shorter way than that which is prescribed by the course of Providence; and he reaps misery as the reward of his furtive attempts to elude the decrees of heaven.

No man can say that he is constrained to do evil by the circumstances in which he is placed: for, as it has been said, *every thing has two handles*, and, according as it is employed, may be the means of good, or the instrument of evil. A man's virtue and happiness are ruined, we shall suppose, in certain circumstances; and it is common for him to say, and for the world to believe him, that had he not been placed in such circumstances, he would have been happy and good. But it is not his circumstances, nor consequently the appointments of heaven, which he ought to blame; for he may see thousands, both virtuous and happy, in the same circumstances in which he ceased to be either.

Let no man then blame necessity for his sins. He is almost constrained to be virtuous: if the constraint were complete, he would not be a moral agent, nor the same being that he now is.

We readily admit that there are many things in the economy of the Divine administration which it is quite impossible for finite understandings to comprehend; and to no subject is this observation more applicable than to the one we are now considering. For we admit most readily, that could we even demonstrate the view of the subject we have adopted, and which we think might be brought as near to demonstration as any point in morals or religion can be, yet even then difficulties would not be wholly removed: nor will we presume to say that we can satisfactorily explain all the ways of God on our plan. We believe the same admission will be made by every candid disputant on the other side; and the question comes to be, which scheme presents fewest difficulties, and solves the greatest number of doubts. The doctrine of necessity is by no means the most popular, but we are fully convinced that it is by far the most philosophical, and that its antagonist doctrine cannot stand before it in point of argument. The objections to *necessity* are all of a popular cast; and in removing them it will generally appear that we demolish the opposite doctrine.

If the advocates for liberty say that it consists in *a man's willing what he pleases*, and this is their common language, no necessitarian can have any dispute with them on this point: the proposition is intuitively true, or rather it is a truism—for a man never can will any thing but what he pleases, unless it were possible for him to will and not to will the same thing at the same time. Whatever a man wills must, at the moment, please him, or he must consider it most eligible at the time—in fact, the expression is tantamount to saying that *a man chooses what he chooses*. Whatever volition the mind forms must be consistent with its choice, for choice and volition *are* the same thing: *they imply the determination or election which the mind has formed*, and, therefore, whenever volition is exerted, liberty is at an end. The mind has already received its impulse—it is already in action, and the quiescence, and indifference, supposed to be essential to liberty, have completely vanished.

The proper question then is, What is it that induces the mind to will? And we think it ought to be admitted as an axiom, that if it is swayed by any thing external to it, and independent of it, or even if it is swayed by any thing essential to its own nature, in neither of these views can it be said to be free, in the sense in which freedom is usually understood, as applied to the human mind. Indeed, it seems to be a most unreasonable freedom that is contended for; it must arise without a cause from the *self-determining* power of the mind. Now, a self-determining power cannot be influenced by any thing, otherwise it is not self-determined; and if it is not influenced by any thing, then it is a power existing without a cause, of which we can have no conception, except in the case of the Supreme Being.

Considering the subject speculatively, one might perhaps be at a loss to determine which of the two schemes is most likely to be abused; for we think it should equally exempt a man from responsibility, to suppose that he has *insufficient* motives to influence his conduct, or that he is bound by *absolute irresistible necessity.* If the author of our nature has not given us sufficient inducements to rectitude of conduct, or, in other words, if he has not presented motives sufficiently powerful to influence our will, we cannot well see how we should be answerable for the want of proper volitions; if, on the other hand, our wills are *absolutely* controlled, there could be no such things as virtue or vice in the world.

As we have ventured to take a side in this very difficult question, we shall rest satisfied with vindicating our peculiar views from the objections which have frequently been urged against them. And, first, it is said that necessity is altogether inconsistent either with praise or with blame. *Physical necessity*, or coercion, is undoubtedly inconsistent with praise or blame. But this is not the case with *moral necessity*, otherwise we could not ascribe praise and glory to the Most High, who undoubtedly acts under a moral necessity, for it is *impossible* for him to do evil; not that he wants the power to do so, but because it is impossible for a being infinitely wise and good, ever to have an *inclination* to do evil; and, according as a man advances in wisdom and goodness, he comes so much nearer to a moral necessity of doing what is right, which, instead of being a defect, constitutes the perfection of his nature. Habits and prepossessions in favour of virtue, which undoubtedly destroy the equilibrium of indifference, and consequently impair or destroy the freedom of the will, so far from lessening our ideas of the worth of the agent, increase them in the highest degree; and where we see a fixed and determined bias to virtuous actions, there we place our highest veneration and esteem. On the other hand, a man who is habitually vicious, and so strongly biassed and inclined to evil, as to be incapable of virtuous exertion, is always viewed with additional abhorrence, instead of being considered as excused by the moral inability under which he labours. Moral inability, then, is never considered as any excuse for wickedness, and the nearer it approaches to moral impossibility, the character is considered as so much the more infamous.

The argument may be carried farther still. "If it be supposed that good or evil dispositions are implanted in the hearts of men by nature itself, yet it is not commonly supposed that men are worthy of no praise or dispraise for such dispositions: although what is natural is undoubtedly necessary, nature being prior to all acts of the will whatever. Thus, for instance, if a man appears to be of a very haughty or malicious disposition, and is supposed to be so by his natural temper, it is no vulgar notion, no dictate of the common sense and apprehension of men, that such dispositions are no vices or moral evils, or that such persons are not worthy of disesteem, or odium, or dishonour, or that the proud or malicious acts which flow from such natural dispositions, are worthy of no resentment. Yea, such vile natural dispositions, and the strength of them, will commonly be mentioned rather as an aggravation of the wicked acts that come from such a fountain, than an extenuation of them. Its being natural for men to act thus, is often observed by men in the height of their indignation; they will say, 'It is his very nature; he is of a vile natural temper; it is as natural to him to act so, as it is to breathe; he cannot help serving the devil.' But it is not thus with regard to hurtful, mischievous things, that any are the subjects or occasions of by natural necessity, against their inclinations. In such a case, the necessity, by the common voice of mankind, will be spoken of as a full excuse. Thus, it is very plain, that common sense makes a vast difference between these two kinds of necessity, as to the judgment it makes of their influence on the moral quality and desert of men's actions."*

In the *second* place, it is said that the scheme of necessity is inconsistent with the use of means, and that if virtue or vice come to pass by necessity, it must be useless to employ any means to obtain the one or avoid the other. This is a very groundless objection, and may, with great advantage, be retorted on the opposite scheme. The whole scheme of necessity proceeds on the idea, that there is a necessary connection between means and ends, antecedents and consequents. "Itaque tantum abest, ut prædeterminatio seu prædispositio ex causis necessitatem inducat contrariam contingenti vel libertati aut moralitati; ut potius in hoc ipso distinguatur *fatum Mahometanum* a Christiano, absur-

* Edwards on Free Will.

dum a rationali; quod Turcæ causas non curant; Christiani vero et quicunque sapiunt, effectum ex causa deducunt. Turcæ silicet, ut fama est, (quanquam non omnes sic desipere putem,) frustra pestem et alia mala evitari arbitrantur; idque eo praetextu quod futura vel decreta eventura sint, *quicquid agas aut non agas*, quod falsum est: cum ratio dictet eum qui certo peste moriturus est, etiam certissime causas pestis non esse evitaturum. Nempe, ut recte Germanico proverbio dicitur, mors vult habere causam." Leibnitz.

It is, then, evidently inconsistent to object to the necessitarian that his scheme renders means unavailing, when he holds that there is a necessary connection between means and ends, motives and action: that when certain means are employed, certain ends will follow; and that certain motives will as certainly lead to particular actions. With much greater justice may it be said, that the opposite scheme supersedes the use of means; for if there be no fixed and established connection between means and ends, and the advocates for liberty are bound to maintain that there is not, for on any other supposition, their scheme falls to the ground; then, it would follow, that it matters not what means are employed, or whether any are employed at all. There could be no such thing as acting with wisdom or prudence, if we did not see an established connection between certain actions or events in the shape of means, and others which depend upon them as their consequents.

We apprehend it is time to close this discussion. We readily admit that the scheme of necessity which we have adopted has often been abused and perverted, by bad men, to the worst of purposes: the Turkish view of predestination is neither more nor less than a gross abuse of the doctrine of necessity: and it is certain that ignorant religionists have perverted it in the same way in many Christian countries. We have endeavoured to vindicate the doctrine from such misconceptions: and though we readily admit that there are many difficulties on the subject of moral agency, which we cannot pretend to explain, yet we think there are fewer on the scheme of necessity, when rightly understood, than on the generally received views of liberty.

Our readers will thank us for presenting them with the opinion of a very acute writer* on this subject, who conveys much weighty matter in small compass, and states some important considerations, which ought to be taken into view by disputants on both sides of the question. "So far as these necessarians maintain the certain influence of moral motives, as the natural and sufficient means whereby human actions, and even human thoughts, are brought into that continued chain of causes and effects, which, taking its beginning in the operations of the infinite mind, cannot but be fully understood by him; so far they do service to the cause of truth; placing the great and glorious doctrines of foreknowledge and providence—absolute foreknowledge, universal providence, upon a firm and philosophical foundation." Thus far we profess ourselves the advocates for necessity, and we assent fully to the following observations, which are both just and profound. "But when they go beyond this, when they would represent this influence of moral motives as arising from a physical necessity, the very same which excites and governs the motions of the inanimate creation—here they confound nature's distinctions, and contradict the very principles they would seem to have established. The source of their mistake is this, that they imagine a similitude between things which admit of no comparison—between the influence of a moral motive upon the mind, and that of mechanical force upon matter. A moral motive and a mechanical force are both indeed causes, and equally certain causes each of its proper effect; but they are causes in very different senses of the word, and derive their energy from the most opposite principles. Force is only another name for an *efficient* cause; it is that which impresses motion upon body, the passive recipient of a foreign impulse. A moral motive is what is more significantly called the *final* cause, and can have no influence but with a being that proposes to itself an end, chooses means, and thus puts itself in action. It is true, that while this is my end, and while I conceive these to be the means, a definite act will as certainly follow that definite choice and judgment of my mind, provided I be free from all external restraint and impediment, as a determinate motion will be excited in a body by a force applied in a given direction. There is in both cases an equal certainty of the effect; but the principle of the certainty in the one case and in the other is entirely different, which difference necessarily arises from the different nature of final and efficient causes. Every cause, except it be the will of the Supreme Deity, acting to the first production of substances—every cause, I say, except this acting in this singular instance, produces its effect by acting *upon* something; and whatever be the cause that acts, the principle of certainty lies in a capacity in the thing on which it acts, of being affected by that action. Now, the capacity which force, or an efficient cause, requires in the object of its action, is absolute inertness. But intelligence and liberty constitute the capacity of being influenced by a final cause—by a moral motive; and to this very liberty does this sort of cause owe its whole efficacy, the whole certainty of its operation; which certainty never can disprove the existence of that liberty upon which it is itself founded, and of which it affords the highest evidence."

The following observations also, by the same author, on the general aspect of the question, are both moderate and judicious, and highly deserving of the attention of every one who engages in this controversy. "The liberty of man and the foreknowledge of God are equally certain, although the proof of each rests on different principles. Our feelings prove to every one of us that we are free: reason and revelation teach us that the Deity knows and governs all things—that even 'the thoughts of man he understandeth long before,' long before the thoughts arise—long before the man himself is born who is to think them. Now, when two distinct propositions are separately proved, each by its proper evidence, it is not a reason for denying either, that the human mind, upon the first hasty view, imagines a repugnance, and may perhaps find a difficulty in connecting them, even after the distinct proof of each is clearly perceived and understood. There is a wide difference between a paradox and a contradiction. Both, indeed, consist of two distinct propositions, and so far only are they alike: for of the two parts of contradiction, the one or the other must necessarily be false; of a paradox, both are often true, and yet, when proved

* Bishop Horseley.

to be true, may continue paradoxical. This is the necessary consequence of our partial view of things. An intellect to which nothing should be paradoxical would be infinite. It may naturally be supposed that paradoxes must abound the most in metaphysics and divinity, *for who can find out God unto perfection?* Yet they occur in other subjects; and any one who should refuse his assent to propositions separately proved, because when connected they may have been paradoxical, would, in many instances, be justly laughed to scorn by the masters of those sciences which make the highest pretensions to certainty and demonstration. In all these cases there is generally, in the nature of things, a limit to each of the two contrasted propositions, beyond which neither can be extended without implying the falsehood of the other, and changing the paradox into a contradiction; and the whole difficulty of perceiving the connection and agreement between such propositions arises from this circumstance, that, by some inattention of the mind, these limits are overlooked. Thus, in the case before us, we must not imagine such an arbitrary exercise of God's power over the minds and wills of subordinate agents, as should convert rational beings into mere machines, and leave the Deity charged with the follies and the crimes of men, which was the error of the Calvinists: nor must we, on the other hand, set up such a liberty of created beings, as, necessarily precluding the divine foreknowledge of human actions, should take the government of the moral world out of the hands of God, and leave him nothing to do with the noblest part of his creation, which hath been perhaps the worse error of some who have opposed the Calvinists."

We have only to remark on this passage, that had the ingenious author considered attentively the work of Jonathan Edwards on Free-will, he would not have supposed that the Calvinists hold the doctrine of necessity in the unqualified and unguarded sense which could lead to the conclusions which he has stated above. Edwards is a very high Calvinist, yet he not only rejects the pernicious consequences which are supposed to flow from necessity, but shows, with irresistible power of argument, that they do not follow from the doctrine, when judiciously and consistently explained. His work, however, seems to be but little known to philosophers, probably because it is supposed to be more intimately connected with divinity than with philosophy: it is, however, by far the most profound work that has ever been written on the question; but it is, at the same time, exceedingly dry and repulsive; and no man need attempt to read it who has not a mind capable of being delighted with naked metaphysical truth. (*g*)

MOR

MORAT, or MURTEN, is the name of a village and lake in Switzerland, in the canton of Fribourg, and on the great road from Lausanne to Berne. The town is situated on the banks of the lake. Many Roman antiquities are found in the neighbourhood, particularly at Monchwyler. In the chateau are six inscriptions, which renders it probable that this place was formerly one of the fauxbourgs of Aventicum. The village is celebrated by the battle of Morat, which was fought on the 22d June, 1476, between Charles the Bold, duke of Burgundy, and the Swiss, who routed and almost destroyed the French army. The bodies of the slaughtered Burgundians were buried in deep ditches; but four years after the battle, an ossuary, (which has been called the Charnel house of Morat,) 10 feet long, and 14 wide, was erected a quarter of a mile from Morat. In 1755, it was repaired by the cantons of Berne and Fribourg; but it was destroyed by the French army in 1798.

The lake of Morat is two leagues long, half a league wide, and twenty-seven fathoms deep; and, according to De Luc, it is about 15 feet above the level of the lake of Neufchatel. The river Broie runs from the lake of Morat to that of Neufchatel. There are many fish in the lake, and it contains a great number of the highly esteemed fish, the *Silurus Glanis* of Linnæus. See Ebel's *Manuel du Voyageur en Suisse*, tom iii. p. 524, and Cox's *Travels in Switzerland*, vol. ii. p. 157, &c.

MORAVIA is a province of the Austrian empire, including Moravia Proper and Austrian Silesia, which has been annexed to it. Moravia Proper contains 8,860 square miles, and 1,334,000 inhabitants; and Austrian Silesia 1840 square miles, and 347,000 inhabitants. The six circles of Brunn, Olmutz, Hradisch, Prerau, Znaym, and Iglau, form Moravia Proper, while Austrian Silesia is divided into the circles of Teschen and Troppau. The following is the population of the principal towns:—

Brunn	26,000	Teschen	5,400
Olmutz	11,000	Znaym	5,200
Iglau	11,000	Cremsier	3,200
Troppau	10,000	Fulneck	3,100
Sternberg	8,000	Prerau	2,900
Nikolsburg	7,600	Hradisch	1,700

Moravia is intersected by several ranges of mountains, between which are many fertile vallies; and in the north and south there are well cultivated plains of considerable extent. The principal river is the March, or Morava, which is navigable, and after receiving the Theya, runs south, and falls into the Danube above Presburg.

This province is not famous for its productions. Corn and flax are raised, but not in very great quantities. Hogs and geese are exported to a great extent. Gold and silver mines were once wrought here, but the most productive ones are those of iron and lead. Coal is found in great quantity, but the veins have not been wrought to a great extent. Fossil remains, a species of amber, and clay for tobacco pipes, are some of the other productions of the province.

The manufactures of Moravia are considerable. Woollen, cotton, and linen goods, are made to a great extent. About 40,000 pieces of woollen goods are woven annually in the neighbourhood of Iglau. The number of persons employed in Moravia in the woollen manufactory is 16,000 in weaving, and 24,000 in spinning. Thread is made at Rothwasser, and dyeing is extensively carried on at Brunn. The cotton works of Lettowitz give employment to 1000 individuals. Leather, paper, potash, and glass, are among the other manufactures of the province. The principal imports are wool, silk, flax, cotton, and oil.

The inhabitants of Moravia are Germans, Sclavonians, and Jews, of whom there are about 30,000.

MORAYSHIRE, or MURRAYSHIRE, or PROVINCE OF MORAY—a maritime county in the northern part of Scotland, bounded on the north by the Moray Firth, on the east and south-east by Banffshire, on the south and south-west by Inverness-shire, and on the west by Nairnshire and Inverness-shire. It lies between the 57° and 58° of North Latitude; and the longitude at the mouth of the Spey is 3° 6′ West, extending in length from East to West 42 miles, and in breadth 20 miles.

The county of Moray is naturally divided into the upper and champaign districts. *1st*, The low country is a large plain, bounded by the Firth of Moray on the north, and a winding range of mountains on the south, whose length equals that of the whole county, and its breadth, measured at right angles from the mountains to the shore, is from 5 to 12 miles, or mean breadth 7 miles. The surface of the low lands is diversified by intervening hills, disposed in short ridges parallel to the Firth, and intersected by the rivers Spey, Lossy, and Findhorn, whose streams wind at unequal distances. across the plain into the sea. Many of the plains along the banks of the Spey and the Findhorn are remarkable for their beauty and fertility. One-third of the bottoms and sides of the valleys within the range of the mountainous or hilly district, except certain parts adapted for bearing trees, is capable of cultivation. The width and depth of these valleys are proportionate to the largeness of the rivers, and the friability of the soil through which they flow.

The climate is so mild, that the apricot, nectarine, and peach, ripen sufficiently on a wall in the open air, and gardens are formed, and fruit trees cultivated, if the length of the lease permits the farmers to make such an arrangement. The most prevailing winds are from the west and north-west, which continue, during the year generally for the space of 260 days, and in the summer the gale is frequently from the south-west, whilst in autumn and winter it is commonly from the north-west, and often rises into a violent tempest, with rain, sleet, or snow. The heaviest and longest rains are from the north and north-west, and thunder showers and drizzling wet weather proceed from the south or south-east An easterly wind is sometimes attended with a heavy flood, and the north wind is often cold and fair, with occasionally *severe* rains. A dry parching easterly wind prevails in general towards the end of spring, blasting the corn, grass, and blossoms, through the whole district. The mean quantity of rain is 25.28 inches, or from 20.06 to 33.17 inches, during a space of nine years. The average depth of rain in the hilly districts is five or six inches greater than that on the coast. The sowing of corn continues from the 2d of March to the 10th April, and the harvest from the 28th August to November 4th. The crops are sometimes damaged in the month of August by a most destructive mildew, occasioned by vapours arising from stagnating streams, which, settling on the unripe corn, injures the milky substance in the ear, and, unless removed by brisk gales or heavy showers, blasts the hopes of the farmer. Few crops suffer from excess of rain; and no instance of any loss from this cause occurred during a period of 38 years, from 1744 to 1782. The county of Moray afforded a large supply of grain for the adjoining counties, when the very wet and cold seasons, towards the end of the sixteenth century, had produced a famine over the whole kingdom. Oat-meal was bought at that period, to be carried across the Grampian hills, at the rate of 1*l.* 10*s.* for the boil of 150 lb.

The population of Morayshire amounted, in 1755, to 13 982; in 1797, to 14,445; in 1801, to 26,705; and, in 1811, to 28,108.

The agriculture of Morayshire was not neglected during the dark ages, but mills were erected in the year 1200; carts were used, and breweries established, in 1225; and gardens formed in 1232; leases were also granted for five and three lives, in the years 1378 and 1390. The culture of wheat in Scotland was increased by an act of Parliament about 500 years ago, which compelled every farmer who had four yoke of oxen to sow one bushel of wheat; and, in 1565, James Ogilvie, of Findlater, produced on his farm 30 bolls of wheat; and the bishop of Moray had the same year, according to his rental, 10 bolls. This circumstance proves that the agriculture of Moray was in a higher state of improvement at this period than that of some of the counties in the north of England, where wheat was not introduced until more than a century after. The convulsions occasioned by the Reformation prevented the inhabitants of Moray from attending to their agriculture; and it was in such a situation, after the struggle carried on for prelacy by four successive monarchs, as to be almost wholly abandoned during the seven unfavourable seasons which took place towards the latter part of the 17th century, and the beginning of the 18th. Thousands of the inhabitants of this county perished at that time, in the high-ways and streets, in consequence of mere hunger. The magistracy of Elgin established a police for burying, every morning, the bodies of those miserable beings who had fallen victims in the streets to the famine during the night. The bier on which the dead of the adjoining parish of Urquhart were carried to their graves still remains; and it is an ascertained fact, that their ordinary attire served both for the coffin and the shroud.

The surplus oats and barley of this county are sent to Dundee or Leith, and the wheat, amounting to 8 or 10,000 quarters, to London. Salmon are sold to the extent of 25,000*l.* and other articles produce 30,000*l.* The facilities of commerce will be increased, and the navigation rendered less dangerous, by forming a harbour at Burgh-head. Woollen manufactories are established in this district, and some of the workmen are from Yorkshire. Nearly 60,000 stones of wool are carded in the counties of Moray and Nairn, and manufactured for plaiding and domestic purposes. A manufacture of cotton is also established in this county.

There are many druidical cairns, on which sacrifice was offered by the druids, about five feet high and thirty feet in circumference, surrounded with stones fixed in the ground, for preventing them from falling. There are also several mounts or motes, which were the seat on which the druids determined questions in law and property; and in Gaelic they are called *tomavoed*, or court-hill, and in the south, laws, as North Berwick Law, &c. There are also strong holds called duns and sand-hillocks, where, by means of a large fire, they summoned their warriors to repel the invading enemy. The Romans soon relinquished this province (the inhabitants of which they called Vacomagi, and its firth, Vararis,) which could neither gratify their avarice nor ambition; and on this account the only remains of their power are of a military nature. Baths, roads, and inscriptions, which belong to a tranquil age, are not to be found here. Fortified chains of communications, whose origin may be traced to a later period, extend from Burgh to the East Sea by Duffus, &c. to Garran in the Mearns. One of the most magnificent obelisks in Scotland, being 20 feet high and 4 broad, is situated nearly half a mile to the north-east of Forres. On its eastern side there are 6 divisions, whereon are represented horses with their riders, and infantry with bows and arrows, swords, and targets. In the fourth division several men armed with spears guard a number of human heads under a canopy; and in the 6th there is the appearance of horses seized, riders beheaded, and heads thrown under an arched cover. It is supposed to have been erected either as a memorial of the assassination of King Duff, or of a battle fought by King Malcolm II. of Scotland against the Danes in 1008. The ruins of the royal forts at Elgin and Forres still exist. The religious houses in this province are numerous. The cathedral at the east end of Elgin is the noblest specimen of Gothic architecture in the county. The magnificence of the building, the elegance of the sculpture, and the uniformity of the design, afford a lasting monument of the labour and ingenuity of the middle ages. Its length is 264 feet, and the height of the centre tower and spire is 198. The model resembles that of the cathedral at Litchfield, but on a larger scale, and with more ornament. The priory of Pluscardine preserves the plan of the building entire, and the whole occupies nearly 12 acres.

The Norwegians conquered Moray about the year 927, under Sigind, Earl of Orkney. Before this period the Picts occupied the Burgh, a Roman station on the Moray Firth, where they established themselves in great numbers, as appears by the ruins of the houses extending nearly two miles on the sea shore to the east. Other colonies of the same descent mingled with the British, and being driven northward by the Belgæ, Iberians, and Saxons, peopled the province of Moray. Their killing King Malcolm I. at Ulrin, the castle of Forres, and King Duffus, A. D. 966, affords a clear proof of their turbulent character. In the reign of Malcolm IV. about 1160, they rebelled, and on his attacking them submitted; but all the insurgents were transplanted into the other counties of Scotland, from Caithness to Galloway. Malcolm III. and his successors encouraged emigrants of rank from England and the continent, who acquired afterwards a considerable property, and from them many of the nobility and of the ancient families in this province are probably descended. At Forres and Mortelich battles were fought betwixt the Scots and Danes, in the year 1008 and 1010. At Speymouth, in the years 1078 and 1110, wars took place betwixt the king and the inhabitants of Morayshire. King Malcolm contended with the same people on the muir of Urquhart in the year 1160. The Frazers and M'Donalds opposed each other at Ceanlochlochie, in A. D. 1544. A contest took place between the king and the earls of Huntly and Angus, in 1594; the Covenanters attacked Montrose in 1645: and in 1690 the king's troops opposed the Highlanders.

The diocese of Moray comprehended the counties of Moray, and a great part of Banff and Inverness, which had fifty-six pastoral charges. There was an abbey at Kinloss, and the abbot had a seat in parliament. Three priories were founded at Urquhart, Pluscardine, and Kinguissie, and likewise several convents. An hospital was also erected near Elgin for entertaining strangers, and for the support of poor infirm people. The monks are said to have possessed excellent libraries. The furniture of Kinloss Abbey consisted of fifty feather beds, two silk beds, and twenty-eight arras coverings. Great hospitality marked the conduct of its inmates, with whom King Edward I. resided nearly a month and a half. The king and his attendants are reported to have drank, during this short period, the beer of more than twenty chalders of malt. Though this statement appears to be exaggerated, yet it affords a decisive proof of the good cheer in which our ancestors of the 14th century indulged.

See Pennant's *Tour.* The *Statistical Account of Scotland.* Rev. Mr. Leslie's *General View of the Agriculture of the counties of Nairn and Moray. Account of the Antiquities*, &c. *in the Province of Moray. A Survey of the Province of Moray. Historical, Geographical, and Political.* Dr. Shaw's *Account of Morayshire.* Chalmers's *Caledonia.* See Nairn

MORBIHAN, one of the departments of the north-west region of France. It was formed out of the Bishopric of Vannes, and is bounded on the north by the department of the Cotes du Nord, on the east by that of the Lower Loire and the Ille and Vilaine, on the south-west by the Ser, and on the west by the department of Finisterre. The department is watered by the rivers Vilaine and Blavet, and produces rye, flax, cattle, horses, fish of all kinds, and has mines of lead and coal. The fertile island of Bellisle contains 5569 inhabitants. The whole department contains 358 square leagues, and 425,485 inhabitants. The following are the principal places:

	Population.
Vannes, the capital	8,728
L'Orient	19,922
Ploermel	4,512
Pontivy	3,090

The forests occupy from 37 to 38 thousand acres, the greater part of which belong to individuals. The contributions in 1803 were 2,327,248 francs.

MORDANTS. See Dyeing.

MORE, Sir Thomas, Lord High Chancellor of England, was the son of Sir John More, Knight, one of the Judges of the King's Bench. He was born in London, in the year 1480, and educated first at a school at St. Anthony's in Threadneedle Street, and afterwards at Oxford, where he soon acquired a considerable proficiency in classical learning; and being destined for the profession of the law, he came to New Inn in London, from whence, after some time, he removed to Lincoln's Inn, of which his father was a member. Having obtained a seat in parliament, he distinguished himself, in the year 1503, by his opposition to the motion for granting a subsidy and three fifteenths for the marriage of Henry VII's eldest daughter Margaret to the King of Scotland. The motion was rejected; and the king was so violently offended at this opposition, that, in revenge, he sent Mr. More's father, on a frivolous pretence, to the Tower, and obliged him to pay 100*l.* for his liberty After being called to the bar, he was appointed law reader at Furnival's Inn, which place he held about three years; and about the same time, he also read a public lecture in the church of St. Lawrence, Old Jewry, upon St. Austin's treatise *De Civitate Dei.* At one time he seems to have formed the design of becoming a Franciscan friar; but he was afterwards dissuaded from it, and married Jane, the eldest daughter of John Colt, Esq. of Newhall, in Essex. In the year 1508, he was appointed judge of the Sheriff's Court in the city of London, was made a justice of the peace, and attained great eminence at the bar. In 1516, he went to Flanders in the retinue of Bishop Tonstal and Dr. Knight, who were sent by King Henry VIII. to renew the alliance with the Archduke of Austria, afterwards Charles V. On his return to England, Cardinal Wolsey wished to engage Mr. More in the service of the crown, and offered him a pension, which he declined. It was not long, however, before he accepted the place of master of the requests. He was also created a knight, admitted a member of the privy council, and, in 1520, made treasurer of the exchequer. About this time he built a house on the banks of the Thames, at Chelsea, and married a second wife.

In the 14th year of Henry VIII. Sir Thomas More was appointed Speaker of the House of Commons, in which capacity he had the courage to oppose Wolsey, in his demand of an oppressive subsidy. Soon afterwards, however, he was made chancellor of the dutchy of Lancaster, and treated with great familiarity by the king. In the year 1526, he was sent, with Cardinal Wolsey and others, on a joint embassy to France; and, in 1529, with Bishop Tonstal to Cambray. Notwithstanding his opposition to the measures of the court, he was appointed chancellor in the following year, after the disgrace of Wolsey. In 1533, however, he resigned the seals, probably to avoid the danger of refusing his sanction to the king's divorce. He now retired to his house at Chelsea; dismissed many of his servants; sent his children, with their families, whom he seems to have maintained in his own house, to their respective homes; and spent his time in study and devotion. But he was not long permitted to enjoy tranquillity. Though now reduced to a private station, and even to indigence, his opinion of the legality of the king's marriage with Anne Boleyn, was deemed of so much importance, that various attempts were made to procure his approbation; but these having proved ineffectual, he was, along with some others, included in a bill of attainder in the House of Lords, for misprision of treason, by encouraging Elizabeth Barton, the nun of Kent, in her treasonable practices. His innocence in this affair, however, appeared so clearly, that they were obliged to strike his name out of the bill. He was then accused of other crimes, but with the same effect; until, upon refusing to take the oath enjoined by the act of supremacy, he was committed to the Tower; and, after fifteen months imprisonment, was tried at the bar of the King's Bench for high treason. The proof rested on the single evidence of Rich, the solicitor-general, whom Sir Thomas, in his defence, sufficiently discredited. The jury, however, brought him in guilty; he was condemned to suffer as a traitor, and was accordingly beheaded on Tower Hill, on the 5th of July, 1535. His body was first interred in the Tower, but was afterwards begged and obtained by his daughter Margaret, and deposited in the chancel of the church at Chelsea, where a monument, with an inscription written by himself, had been some time before erected, and is still to be seen. The same daughter also procured his head, after it had remained fourteen days upon London bridge, and placed it in a vault belonging to the Roper family, under a chapel adjoining to St. Dunstan's church in Canterbury.

Sir Thomas More was a man of considerable learning, eminent talents, and inflexible integrity. Although possessed of great sagacity in other matters, his religious bigotry exposed him to superstition and credulity. When only twenty years old, he was so devoted to monkish discipline, that he wore a hair shirt next his skin, frequently fasted, and slept upon a bare plank. Yet his disposition was cheerful, and he had an affectation of wit, which he could not restrain even upon the most serious occasions. He was the author of various books, chiefly of a polemical nature. His *Utopia* is the only performance that has survived in the esteem of the world. Hume says of him, that of all the writers of that age in England, Sir Thomas More seems to come the nearest to the character of a classical author. His English works were collected and published by order of Queen Mary, in 1557; his Latin at Basil, in 1563, and at Louvain, in 1566. A life of Sir Thomas More, by his son-in-law, Mr. Roper, of Wellhall, in Kent, was published by Mr. Hearne, at Oxford, in 1716. (*z*)

MOREA, a peninsula of a very irregular form, sometimes compared to the shape of a Mulberry-leaf, and joined to the continent by a narrow neck of land, called the Isthmus of Corinth, is situated between 36° 29′ and 38° 30′ North Latitude, and between 21° 30′, and 24° of East Longitude from Greenwich. Its greatest extent, from the Gulf of Lepanto to Cape Matapan, is about 120 miles, and its greatest breadth 110; but its coast is deeply indented by numerous gulfs, inlets, and bays. It is divided into four provinces, namely, Chiarenza, Belvidere, Tzakonia, and Romania Major. In Chiarenza, which includes all Achaia Propria, the principal places are Saraoalle, Triti, and Caminitza, which are only inconsiderable villages. In Belvidere, which contains Elis and Messenia, there are Larissa, on a river of the same name; Chiarenza, (Cyllene,) at the bottom of a gulf of that name; Tornese, a village with a castle on an eminence near a cape of the same name; Gastouni, a considerable town south from the river Peneus; Callivi (supposed to be the ancient Elis;) Belvidere, a considerable town in a delightful situation; Rofeo, near the site of the ancient Olympia; Arcadia, on the bay of the same name; Navarini, with a large commodious fort in its vicinity; Modon, a small fortified trading town, with a good harbour; Coron, a little town, well defended, near a gulf of the same name; Messene, once the capital of Messenia, now a small hamlet called Mavra-Matea, near Mount Vulcano; and Calamatia, an open town on the river Stromio. In Tzakonia, which includes Arcadia and Laconia, are Misitra, near the ruins of ancient Sparta, defended by a castle containing several public edifices; Cyparissi, (Tyros,) on the Gulf of Napoli; Malvasis-Vecchia, a little town under a strong citadel, on a small island connected with the Continent by a bridge, from the neighbourhood of which place comes an excellent wine, called Malvoisia or Malmsey; Colokythia (Gythium,) a small town on the west coast of a gulf so named; Maina, a town and district on the north of Cape Matapan, inhabited by an independent and warlike tribe, called Mainotti or Mainottes, supposed by some to be descendants of the Spartans, but who are more probably sprung from some Slavonian horde. Leondari, a village on Mount Taygetus; Trapolissa, which may be regarded the modern capital of the Morea, near the site of Tegda; Orchomenus, Phonia, and Gardena. In Romania Major, which comprehends Corinth, Sicyon, and Argos, are Corito, (Corinth) on the high ground which looks down upon the gulf of Lepanto; Vasilica (Sicyon) containing a few mean dwelling houses; Staphlica (Phlius) an inconsiderable village at the foot of mount Gromo; Vostitza (Ægium) a small place on the border of the gulf; Drepano, a village with a harbour near the promontory of the same name; Patras, a trading town containing about 4000 inhabitants, to the westward of Lepanto; Argolis, a town of considerable extent, but without any vestige of its ancient edifices; Agios, Adrianos, or Charia, (Mycene) now a small hamlet; Nemea, where there are some ruins of the ancient city of that name; Napoli di Romania, (Nauplia) a trading town, strongly fortified, with a spacious and secure harbour; Pidavra (Epidaurus) a little town in the recess of the gulf of Argos, naturally strong, provided with a tolerable port; Damala, Castri, and Hydra, places of little note, except that the inhabitants of the last mentioned are remarked as excellent sailors.

The present appearance of the Morea, as far as respects the natural features of the surface, corresponds very exactly with the description given of it in the Itinerary of Pausanias; but the country appears remarkably diminutive, when contrasted with the great events in Grecian history. The mountains of Greece are uniformly composed of limestone; and of that kind of formation which is supposed to be peculiarly liable to the phenomena of earthquakes. The valleys are vast basins, surrounded by circles of these mountains, and the country is thus divided into a number of distinct craters, each of which contains a spacious level area, naturally fitted for a separate community. Its surface is compared by Dr. Clarke to a number of saucers with broken lips, placed together on a table. Excepting the Pamesus, Cephisus, and Eurotas, the rivers of the Morea are exhausted; and are nothing more than little streams, with almost dry channels in summer, but rapid torrents in winter.

There are no Greek or Roman roads perceivable in the Morea: but only Turkish causeways about two feet and a half in breadth, leading over the low marshy spots; and these are sufficient for the horses of the soldiery, or the asses of the peasantry, who rarely make use of any wheel carriages.

The climate, and the whole aspect of nature in the Morea, presents a harmonious uniformity, softness, and repose, and the scenery is often beautiful. The soil in the valleys is fruitful, and susceptible of every species of culture; and the mountains are covered with pasture and medicinal herbs; but only a few of them, particularly Helicon, are adorned with luxuriant shrubs, and covered with thriving flocks. Rose-laurels, and the Agnus Castus, with its long, pale, narrow leaf, and purple woolly flower, are met with all over the country; and are almost the only decorations of its now solitary wastes.

It would be a vain attempt to describe the remains of ancient arts and architecture in modern Greece; where every species of destruction follows another so rapidly, that frequently one traveller can discover no trace of the monuments which another had admired but a few months before.

The population of the Morea has been estimated by some at 300,000, but the following is one of the most recent computations, namely,

400,000	Greeks.
15,000	Turks.
4,000	Jews.
4,000	Mainottes.
423,000.	

The history of this country, from the dissolution of the Achaian league, B. C. 146, is connected with that of Rome; and, after the fall of that empire, is to be sought in that of Venice and Turkey. We notice, at present, only a few of the leading events in its state and history, from the conclusion of its ancient annals, given under the article GREECE, in this work. In the civil wars of Rome, the Athenians espoused the cause of Pompey, which they considered as that of liberty; while the Spartans adhered to the interests of Cæsar, and fought against Brutus at Philippi. Vespasian reduced Achaia to a Roman province, A. D. 79. The laws of Lycurgus were still in force at Lacedæmon in the reign of Domitian, A. D. 91. Adrian, A. D. 134, rebuilt the fallen monuments of Athens, erected a new city in the vicinity of the ancient one, and revived throughout Greece the reign of science and the arts. Under the Antonines the schools of Athens were restored to their former splendour; and the city swarmed with a multitude of philosophers, and their respective disciples. Sparta had fallen into obscurity, except that the emperor Caracalla chose a band of her citizens as his body-guard. In the year 261, the Heruli pillaged the greater part of the Morea, and eight years afterwards, Athens was taken by the Goths, but rescued from their hands by one of its citizens named Cleodemus. In 395, the whole of Peloponnesus fell under the successive ravages of the barbarians; and its devastation was completed by the troops under Stilico, who marched to its deliverance. Justinian made some attempts to repair its ruins; and, when the eastern empire was divided into governments called *Themata*, Lacedæmon became a domain of the brothers, or eldest sons of the emperor, who assumed the title of Despots. From this period, A D. 527, there are few historical records of this renowned region, for the long space of 700 years. In 846, Greece was overrun by the Sclavonians, who are supposed to be the ancestors of the modern Mainottes; and, in 1081, the western coasts were ravaged by the Turks. About the beginning of the 12th century, the Venetians and other western nations invaded the Peloponnesus, which appears, about this time, to have changed its name for that of the Morea, in consequence (as is conjectured) of its abounding in mulberry trees, which then began to be extensively cultivated in the growing manufacture of silk in the country In the commencement of the 13th century, Boniface, Marquis of Montserrat, joined by other bands of Crusaders, reduced the whole of the Morea, which was soon after given up to the Venetians by the terms of a general treaty concluded at Constantinople. Occasionally possessed by different chiefs, called princes of the Morea, it was for 57 years the subject of contention between the Latin emperors of the East, and the Greek emperors who had retired into Asia. Occupied at different times, for short periods, by various adventurers, it fell at length, in the beginning of the 15th century, under the power of the Mussulmans. It was reconquered by the Venetians in 1688, and retained by them till 1715, when it reverted again to the Ottoman empire. In 1770, a last and unavailing attempt was made by its inhabitants, at the instigation of Catharine II. of Russia, to throw off the Mahometan yoke; but the Turkish oppressions have since that period increased in severity, and nothing can exceed the present wretched degradation of the once celebrated people who inhabited the plains of Peloponnesus.

But modern Greece, so long forgotten in history, and obliterated from the list of nations, has attained, in these later ages, a new species of renown; and has become the resort of the learned and ingenious from every land, by the mere attraction of its monumental remains. As soon as the nations of Europe were roused from their barbarism, their attention was directed to the cities of the Morea, as the repository of all that survived of ancient art and ornament. So early as the year 1465, Francesco Gambietti made drawings on vellum of many of these Grecian monuments, which were deposited in the Barberini library at Rome, and which are the more curious and valuable, as they were taken when these structures were still entire. In 1550, Nicholas Gerbel published at Basil a description of Greece. In 1584, Martin Crusius, professor of Greek and Latin in the university of Tubingen, in a work entitled Turco-Græcio, gave an account of Greece from the year 1444 to the time in which he wrote. About the beginning of the 17th century, the establishment of French consuls in Attica, and about 50 years afterwards, the arrival of the Jesuit missonaries from the same country, contributed to enlarge the knowledge of Grecian monuments in the Morea. De Monceaux, who visited Greece in 1668, described antiquities, of which not a vestige now remains; and Father Babin, published, in 1672, the most complete and circumstantial account of the city of Athens which had then appeared. But the travels of Ipion and Wheeler, in 1678, presented the ablest view that had been given, in modern times, of Grecian arts and antiquities. At the same time the earl of Winchelsea conveyed several fragments of Grecian sculpture to England; and Vernon, an English traveller, published a rapid sketch of his travels in Greece in the Philosophical Transactions. From this date the travellers in Greece found only the ruins of many of the finest monuments hitherto described by their predecessors, in consequence of the ravages committed by the Venetians in their reconquest of the Morea. In 1728 the Abbé Fourmont was sent to the Levant in quest of inscriptions and monuments, but his work was never published; and Pococke, in 1739, gave one of the most accurate descriptions that had yet been made of Grecian ruins. In 1758, the picturesque tour of Greece by Leroi, a French artist, and, 1761, the more correct views published in Stuart's Antiquities of Athens, made great additions to the topography of modern Greece; but the work of Chandler, a few years afterwards, rendered almost every other account superfluous. During the Russian invasion in 1770, many of the remaining monuments in the Morea were demolished, and succeeding travellers began soon after to carry away every portable fragment of Grecian art, as the only mode of preserving them from more barbarous destroyers. Baron Reidesel in 1773, M. de Choiseul in 1778, Foucherot and Fauvel in 1780, still found something new in addition to former descriptions. The travels of M. Scrofani in 1794, and the works of Pouqueville, who describes however what he did not visit, have rendered modern Greece more fully known in many points of considerable importance; but the numerous researches of English travellers, in every corner of Grecian territory, have furnished a mass of intelligence, which cannot be brought within the compass of an article like the present; and to which we must refer our readers for the fullest information on the subjects so briefly noticed in the following paragraphs.

A few Greek families pretend to trace their descent from the distinguished names who once stood at the head of the Byzantine empire; and are considered as forming a class of Grecian nobility at the present day. To these the Ottoman court has granted four dignities, or high offices, which are a perpetual object of ardent competition among them, and in which they are incessantly intriguing how to supplant one another. These are, the Patriarchate of Constantinople, the office of Dragoman, or chief interpreter to the Porte, and the governments of Moldavia and Wallachia. The first is always procured by simoniacal purchase; the second generally in the same way. The person who enjoys it has the opportunity of recommending to various posts of honour and profit, and receives a due remuneration for every exertion of his influence. The two last, which are commonly bestowed upon the Dragoman, as a reward of his services, are held at the pleasure of the Sultan, and are seldom enjoyed above three years; during which period the Waivodes of these provinces levy great sums by the most arbitrary exactions. However short a period any individual has possessed one of these three secular offices, he retains afterwards the title of prince, with the privilege of wearing yellow slippers, and riding on horseback. In the Morea, the municipal government of certain districts is conferred upon native Greeks, who are entitled Codja Bashees, and who affect considerable state, as well as maintain a numerous household. They have their physician, secretary, assistant clerk, courier, five or six chaplains, and several servants in every department, to the number altogether of 40 or 50 dependents. They are too generally more oppressive and domineering to their countrymen, than even their Turkish masters. The modern Greeks are completely sensible of their degraded state; and discover a strong attachment to their country, as well as an ardent desire of political emancipation. Their ideas, however, go no farther back than the days of the Greek emperors; and they have no view of establishing any independent republics like those of ancient Greece. Their hopes are solely directed to the restoration of the Byzantine kingdom, in the person of any Christian prince, but, particularly one of their own church. For more than half a century they have naturally turned their views towards Russia; but two desperate attempts, in conjunction with the troops of that nation, one in 1770, and another in 1790, proved completely unsuccessful. During the expedition of the French to Egypt, they began to cherish the hopes of liberty through their means; and were ready to have joined their standard in the invasion of Turkey. They made similar advances to the British, during their short war with the Porte in 1807; but, besides receiving no encouragement from the British authorities, they consider them as too distant allies; and still look to the Russians and French as their natural deliverers. Without such foreign aid, they are utterly incapable of asserting their independence. The whole nation is not computed to exceed two millions and a half of all ages and sexes; and even these are so mixed a race, that they are rather a Christian sect, than a distinct people. It is chiefly by means of their marine, that they may regain some weight among other nations; and the establishment of some Christain power in the islands of the Archipelago has long been considered as the likeliest step to the improvement of the Greeks. The French, in consequence of employing only Frenchmen as agents and consuls in the Levant, with good salaries, have the greatest influence with the natives, and it is worthy of consideration how far the interests of Great Britain might not be extended by a similar plan, and by cultivating a close intercourse with the modern inhabitants of Greece and its islands.

The commerce of the Morea, and of modern Greece in general, is greatly fettered by the restraints of the Ottoman government. The Greeks have a flag for their merchant vessels, but not being an independent people, it is little respected by other nations; and their Turkish masters, who are jealous of their power, seldom resent any insult offered to them at sea. They are not permitted to trade farther west than Tunis, Malta, and Messina; and the Algerine corsairs are permitted, by treaty with the Grand Seignior, to capture any of his Grecian subjects who may be found trading to the westward of these ports. Thus unprotected and exposed, they are apt to seek redress at their own hands; and, when insulted by any vessel of superior force, they retaliate cruelly upon any inferior ship belonging to the same nation which may fall in their way. The Morea produces a great variety of articles which are valuable in commerce; and many of them such as are in great request in the British market. Dried fruits of various kinds, almonds, small nuts, gums, galls, and a variety of drugs, are very common articles of traffic. But the larger and more valuable commodities which the country affords, are currants, which are larger and cleaner than those of most other countries, and of which eight millions of pounds weight are said to be annually exported, usually at three halfpence per lb. English; young fustic, a valuable dye wood for bright yellow; cotton in considerable quantities, but rather of an inferior quality; olive oil of a tolerably good quality, and much cheaper than that of Italy and Sicily, generally at £25 per ton; valonia, a kind of acorn used in tanning, and much in demand by the English; corn, wool, silk, carpets, leather, vermilion, wine, wax, cheese, are frequent articles of export.

The articles of import generally carried to the Levant, are watches, jewellery, glass, porcelain, furs, spices, coffee, sugar, indigo, cochineal, sulphur, silk, gold-lace, cloth, muslins, hardware, and other manufactured goods of England and France. The balance of trade is alleged to be one-fifth in favour of the Morea, which is paid in silver coin. Of this amount, two millions of piastres go as tribute to Constantinople; one million is taken by the Pasha of Tripolizza; and the remainder, about 1,093,750 piastres, is the profit of the rich Greeks. The Frank residents are only a sort of brokers, who have a per centage upon the traffic.

The Greeks are universally addicted to commerce, and their marine is in many respects highly important. The islanders form the most enterprising portion of the nation, and carry on a petty trade in numberless half-decked boats, with high stems and sterns, and one thick short mast, with a long yard. They perform these voyages, even as far as Smyrna and Constantinople, without chart or compass, and merely, as of old, by the observation of coasts and headlands. But they are acquainted with the management of the largest vessels of European construction; and, besides navigating the Ottoman navy as seamen, they have large merchant ships of their own, which trade as far as America and the West Indies, and make an occasional voyage to England. The natives of Hydra particularly, the most expert of the Greek mariners, have accumulated great wealth by their commerce, and have purchased from the Turks the independent election of their own magistrates. The number of Greek mariners actually employed at sea, is supposed to be not less than 50,000; and they are considered as capable of being trained to any kind of naval service.

Though the modern Greeks are very ignorant, they are a very ingenious people; and, if rescued from oppression, might again distinguish themselves in the arts and sciences. But, since the 12th century, they have made no improvements, and transmitted no inventions to other nations. Their ancient authors had long lain neglected in monasteries and libraries; their late writers were rather expert grammarians than original authors; and the revival of their literature, in the 14th and 15th centuries, was more owing to the exertions of the Italian literati than of native Greeks. The corruption of the Greek language has been dated from the time of the Macedonian conquest, and is particularly ascribed to the extension of the Roman power; but it appears to have survived as a living language in considerable purity so late as the 11th or 12th centuries. The irruption of the Goths and other barbarians, and the settlement of the Sclavonians and Franks in Greece, occasioned numerous corruptions, about the beginning of the 13th century; and the establishment of the Ottoman empire introduced many Turkish terms and idioms; but it is not possible to fix the precise period when the distinction between the Hellenic or ancient, and the Romaic or modern dialect, was generally acknowledged. It appears that a multitude of different dialects prevailed in the progress of its corruptions, not less, it is said, than seventy; and that the Romaic did not become an established language till about a century after the Turkish conquest. The first instance of it, as a written language, is a translation of the four apologies of John Catacuzenus into the vulgar tongue by Meletius Syrigus, a Cretan, who died in 1662. The earliest and best of the grammars of this new language is that of Portius, also a native of Crete, which may be seen in the glossary of Du Cange. Besides the introduction of new vocables, the modern dialect drops the inverted arrangement of the words, forms the tenses by the aid of the auxiliary verb, and makes great use of the contractions, so as to blend several words into one. The pronunciation unquestionably became vitiated along with the structure of the language; but the Byzantine Greeks maintain that they still possess the ancient mode of reading it. A sketch of the modern dialect, and of its pronunciation, may be seen in the appendix to *Hobhouse's Travels*, and Dalaway's *Description of the Levant*; but the following specimen of the mode of reading the first lines of Homer, as given by the former writer, may give some idea of the modern pronunciation. The *a* is to be sounded as in the English word *plate*:

Mēnin āedthe Thea Peleiādtheo akelaos
Oolomānen ē merē akœēs ālge ātheke
Pollās d'ipthēmoos psekās āedthe proeāpsen
Erōone, aftoōs dē elōrea tēvke kēnessin
Æonæse te pāse. Dtheōse d'eteléeto voolē.

There are great varieties, however, in the mode of speaking the Romaic. The Greeks of the Morea and on the coasts of the Adriatic, intermix more of the Venetian; and those of the Archipelago or Smyrna, more of the Turkish; while those of the Fanal, in Constantinople, speak it in the most classical style of purity.

Since the establishment of the Romaic, the Greek literature has been extremely limited; and in the course of 150 years previous to the year 1720, about 100 persons have been recorded as men of learning, the greater part of whom, as well as of the later writers, were theological authors, educated in Italy. But, in consequence of the recent communications between the more enlightened nations of Christendom and the Levant, considerable improvements have taken place. About the end of the last century, under the auspices of a prince of the family of Mavro Kordato, who was Hospodar of Moldavia, a dictionary and grammar of the Romaic was published, and several translations of French and Italian novels, printed in that language at Venice or Vienna. A few of the higher Greeks compose pieces in poetry, but rarely for publication; and there is little original composition yet produced among them. Numbers, however, attend the universities of the Continent, chiefly from the Ionian isles; a few of them for the sake of ecclesiastical studies, but most of them for the purpose of qualifying themselves to practice as physicians in their own country. The principal study of the modern Greeks is the acquisition of languages, in which they display a wonderful proficiency; so that many of their young men are able to speak five or six languages at a very early age; and numbers of the lower orders can make themselves understood in French, Italian, Russian, Turkish, Sclavonian, and Latin. A Greek printing press has been established at Bucharest, and another at Venice, for a considerable period; but grammars, dictionaries, theological tracts, vulgar romances, and song books, are the only productions of these establishments. A few learned Greeks in Paris have distinguished themselves by their talents, and have published several translations in Romaic for the benefit of their countrymen; but not more than one or two native authors are known at present to reside in Greece. The principal Romaic books to be found there, are translations of Beccaria *On Crimes*, Locke's Essay, Montesquieu's *Rise and Fall of the Roman Empire*, Rollins's *Ancient History*, Telemachus, *Plurality of Worlds*, Goldsmith's *Grecian History*, *Robinson Crusoe*, the *Arabian Knights*, an original *Life of Suvaroff* by a merchant in Athens, and a journal printed at Vienna, besides the ordinary catechisms and homilies of the church. But there are no shops for purchasing books, and scarcely any thing like a library, public or private, in the country. There is no dissemination of knowledge among the natives of Greece, except by means of one or two schools in some of the larger towns, where the ancient Greek, and sometimes Latin, with the modern languages, are taught. Most of them can read and write, so as to be qualified for the service of their pashas, and the transactions of their petty commerce, but have no knowledge of books, or attainments in science. They can all compose a song or lampoon; but their best productions have more of the oriental imagery than the Greek simplicity; and all their poetry is full of the worst kind of taste. Their prose writings are insipid, and chiefly distinguished by copiousness of words.

The state of the arts in Greece is very low; and it is said, that there is not a sculptor, painter, or architect to be found, equal to the common workmen in the towns of Christendom. Their paintings are chiefly gilded saints; and the best are to be seen at Scio.

Medicine is practised by Italians, or by native Greeks, who have received some education in Italy; or even by persons of no education, but who, having failed in other pursuits, put on the Frank habit, and assume the office of physicians. In most of the towns there is at least one of these persons, who is paid so much per annum for taking care of the health of the whole inhabitants. The general practice is, to administer jalap, manna, glauber salts in small quantities, draughts of bark in almost every complaint, allowing the patient at the same time plenty of fat broths. Phlebotomy is often used, but not topical bleedings. When the disease is of long continuance, or if the least delirium appears, the patient is considered as possessed; and instead of the physician, the priest is employed to exorcise the evil spirit. Pestilential fevers, elephantiasis, leprosy, and the plague, are seldom attempted to be cured by medical skill. The frequent use of the warm bath, to which the natives are much addicted, is probably more prejudicial than salutary to their health.

The Greek music is plaintive, but very monotonous; and it is doubtful whether most of their airs may not be of modern origin. They sing through the nose, and in a confused manner, men and women all joining together. Of many tunes borrowed from the French and Italian, it is said they never go beyond the first part. "They have an admirable *kyrie eleison*," says Chateaubriand. "It is but one note, kept up by different voices, some bas and some treble, executing *andante* and *mezza voce*, the octave, the fifth, and the third. The solemn and majestic effect of this *kyrie* is surprising. It is doubtless a relic of the ancient singing of the primitive church." The fiddle and lyre, or three-stringed guitar, are the usual instruments upon which most of the young men, and particularly the sailors, are able to perform. Pan's pipe, and a kind of bagpipe, are also met with in the Levant. Modern travellers give a very unfavourable account of the general strain of music in Greece; Dr. Clarke, particularly, represents it as inferior to that of any other European nation, except the very lowest in point of civilization and refinement. "The tone of the vocal part," he says, of a certain performer, "resembled rather the howling of dogs through the night, than any sound which might be called musical. And this was the impression made upon us every where by the national music of the modern Greeks, that if a scale were formed for comparing it with the state of music in other European nations, it would fall below every other, excepting only that of the Laplanders, to which, nevertheless, it bears some resemblance."

There is a considerable resemblance in the doctrines and general form of the Greek church, and those of the church of Rome. In the number of the sacraments, the invocation of saints, the belief of the real presence, the practice of auricular confession, the offering of masses for the dead, the division of the clergy into regular and secular, the spiritual jurisdiction of the bishops and their officials, the distinction of ranks and offices among the ecclesiastics, there is very little difference between the churches of Greece and Rome. This resemblance is kept up and increased, in consequence of the number of Greek ecclesiastics who study in Italy; and, in the Morea and Archipelago, there are many Roman Catholic converts among the natives. The Greek clergy are divided into two classes, the Papades, or secular priests, who hold the parishes, and the Caloyers, or monks of St. Basil, who have their seminaries on Mount Athos, in Chios, and the Prince's Islands. The secular priests, contrary to the case in the church of Rome, are the most ignorant and illiterate, while the monks are generally men of a certain degree of education. All orders of the seculars, inferior to bishops, are permitted to marry, provided they choose a virgin, and engage before ordination; but can never rise higher than to the office of proto-papa in the church where they serve. All who aim at a mitre must observe celibacy, and assume the monastic habits.

The parish papas enter into priest's orders by a kind of public election. Being proposed to the congregation or church, the officiating priest asks the audience if he is worthy, and upon their acclamation in the affirmative, he is considered as authorised to enter upon his functions. The chapels, which are very numerous, and some of them little better than a cavern with a door and stone altar, must have each their own priest, who cannot officiate in other places of worship, and who, though more serviceable than the monks, are not so well provided for.

The Caloyers never say mass, and if they take the priesthood, they are called "holy monks," and officiate only on high festivals.* Admission to the brotherhood is obtained by paying to one of these holy monks a sum of 60 or 70 piastres, without any probation or examination, so that young children are allowed to take the habit, as they thus secure, in their miserable country, the certainty of being fed. Their monasteries are frequent objects in the valleys, forests, and hill-sides; and they have farms tenanted by one of their order, in most parts of the country. They subsist partly by the lands attached to the monasteries, and partly by the voluntary contributions of the people. On particular days, they go about with little pictures of their saints, which they give their votaries to kiss, and a jar of holy water with a brush, by which they mark the cross on the foreheads of each person, receiving a para or two from every individual for this service. They abstain wholly from flesh, and observe a very austere mode of living. Most of their time is occupied in a set of superstitious devotional exercises, reciting parts of the Psalter, or bowing and kissing the ground for a certain number of times. Three hundred of these bowings must be performed by each individual in every 24 hours. Their ignorance and simplicity is extreme, and in few of their monasteries have they any books, not even any part of the Scriptures. The most sacred of the Caloyers are those who have received their education in the seminaries of Mount Athos, where there are six thousand of the order, who occupy themselves in studying and in all kinds of mechanical trades. There is no ground for the charge of these monasteries being the abodes of vice. The head of the church is the Patriarch of Constantinople, whom they style the thirteenth apostle, but to whom they attach no personal sanctity or official infallibility. The person admittted to the office is invested in a triumphal mannner by a minister of the Porte; and possesses a kind of absolute authority over the whole native Greeks. His influence with the Sultan is very great, and his applications are generally effectual in every thing relating to his own nation. He can bring any Greek to be punished by fine, deposition from office, imprisonment for life, banishment, or death. This dignity is now regularly exposed to sale, and costs about 60,000 crowns. The Patriarch indemnifies himself by selling the other patriarchates of Jerusalem, Antioch, and Alexandria, besides all the archbishopricks, and every lucrative place within his jurisdiction; a practice which the Greeks themselves introduced, by offering to fill these offices for smaller salaries, or by giving for them greater sums, when vacant. The whole of the Patriarch's usual revenue does not exceed £3,000; (except what fines and extortions may yield,) and the richest bishops do not possess more than £300 a year, which is raised by a direct tax upon every Greek house within their districts. Contributions are made by devout individuals to assist those who make pilgrimages to the holy sepulchre at Jerusalem, and who are afterwards distinguished by the name of "hadje," as among the Turks. The clergy in general have great influence over the people; and receive, on certain days, gifts of loaves, sweet meats, wax tapers, &c.

The rites of the Greek church are in themselves very absurd, and are performed with very little solemnity. There are prayers and portions of scripture, histories of the saints, hymns, and forms for different festivals; but the service consists principally in singing, without musical instruments. In the celebration of the mass, the chief part of the worship consists in crossing and repeating a thousand times, in a combined song, the words, "Lord have mercy upon me." Pictures are admitted into the churches; and great attention paid to the form and colour of the clerical vestments. Their festivals are very numerous, which the people are strictly enjoined to observe: and as most of them are celebrated by dancing and music, they are the great delight of the frivolous natives, under their present oppressions. The sacrament of the eucharist is administered to new born infants, and that of extreme unction is not confined to the dying, but is given to devout persons upon the slightest malady, and even to those who are in full health, by way of anticipation. The laity are devoutly attached to all the ceremonies and ordinances of their church, which are numerous and severe. Wednesdays and Fridays are days of fasting throughout the whole year; and some of the principal fasts, such as Easter and Christmas, continue forty days; so that there are not above 139 days of the year free from all fasts. They are devoted to superstitions, which occupy their minds infinitely more than the great points of their faith. The priests are frequently employed to exorcise persons supposed to be possessed by evil spirits. They all believe in the power of magic, and often fancy themselves to be suffering from the incantations of some malevolent being. Ghosts or fairies, called Arabins, are imagined to haunt houses and other places. They believe in the occasional appearances of angels to make particular revelations. They are all devoted to the worship of the holy virgin; and in al-

* Caloyer is supposed to have been a name of the Grecian priests long before the introduction of Christianity, and to be derived from the words καλὸς ἱερεύς, the "good priest," or καλογεροι, "good old fathers."

most every cottage, her picture or image is to be seen, with a lamp burning before it. Almost all diseases are considered as the effects of demoniacal influence; and the plague particularly is thought to appear in the form of a lame and withered hag.

The churches in Greece have great simplicity; and are generally very small. The floor is of mud, the altar of stone, the sanctuary separated from the nave by deal boards, and an enclosure of pales at the other end made for the women. They are seldom furnished with seats; here there are several crotches in one corner, upon which the aged worshippers support themselves. In the greater towns, and in some of the monasteries, they are fitted up in a better style, but in a bad taste, ornamented with gildings and pictures of saints.

The modern Greeks bear a great resemblance to the descriptions which have been transmitted of the ancient inhabitants of the country, in their bodily appearance, dress, diet, and tempers. There is a national likeness observable among them all, but the islanders are of a darker complexion, and a stronger make, than those of the main land. Their countenances are such as may be supposed to have served for models to their ancient sculptors; and the young men particularly are distinguished by a degree of beauty which would be considered as too effeminate among those of the same age in more northern climates. Their eyes are large and dark, their eye-brows arched, their complexions brown, but clear, and their cheeks and lips tinged with bright vermilion colour. Their faces are a regular oval, and their features perfectly proportioned, except that their ears are rather larger than usual. Their hair is dark and long, but shaved off in the forepart of the crown and sides of the face. Beards are worn only by the clergy and persons of authority, but all of them wear thin long black mustachios on the upper lip. Their necks are long, but broad, and well set, their chests wide and open, their shoulders strong, but their waists rather slender, and their legs large, but well made. Their stature is above the middle size, and their form muscular and round, but not corpulent. The women are inferior to the men, both in face and figure; and though they have the same kind of features, yet their eyes are languid and their complexions pale, their whole persons loose and flaccid, their height rather low, and their forms, as they advance a little in life, fat and unwieldy. Those of the better class are very careful to improve their beauty by paints and washes; but they often lay on their colouring substances to a very unnatural degree.

The dress of the modern Greeks bears a near resemblance to that of the Turks. The under garments are a cotton shirt, cotton drawers, a vest and jacket of silk or stuff, a pair of large loose trowsers drawn up a little above the ancle, and a short sock. Over these are worn large shawls, often richly ornamented, wrapped round the loins, in one corner of which the poorer people frequently conceal their money, and a loose gown or pelisse, with wide sleeves, which, in the presence of a superior, they wrap modestly about their persons, concealing their hands with the sleeves, and resting their chins on their bosoms. The wealthy individuals have pelisses of cloth lined with fur for winter, and who wear purses, which, together with handkerchiefs, watches, snuff-boxes, papers, they carry in their bosom between the folds of the vests, and count it a mark of distinction to have this part of their dress full and distended. They may wear any colour except green, which is appropriated to the descendants of Mahomet, and, instead of a turban, they have a large calpac. The common people seldom use a gown, and have their trowsers so short as to leave their legs bare below the knee. The sailors have nothing but a jacket; and in summer wear the Albanian red scull-cap. The dress of the females bears some resemblance to that of European women, and consists of a vest fitting close to the bosom, but becoming larger and wider below the waist; a gown flowing off loosely behind, with long wide sleeves turned up at the wrist; a ribbon or other girdle under the bosom, a rich shawl, as a zone, wrapped once round the body, resting loosely on the hips, and fastened before with a large plate, or tied in a spreading knot. The dress of the richer females is loaded with gold and silver trimmings, bracelets of precious stones, and strings of gold coins round their necks. The young women have their hair hanging down the back, loose or plaited, combed over the forehead and the sides of the cheeks, and a little red cap, with a gold tassel studded with zequins, on the one side of the crown. When they go abroad, they are muffled up in a wrapping-cloak, with a long veil, but in their private apartments they have their feet naked, and their bodies thinly clothed, as the temperature of the weather may admit. Their toe-nails and finger-tops are stained of a rosy colour, and their eye-lashes with black. No change as to fashion takes place in their dress, but their habits are esteemed entirely in proportion to the price which they cost. The most universal part of Grecian dress, which is also worn by all the inhabitants of the Levant, Mahometans or Christians, males or females, and the sale of which forms a principal article of Grecian commerce, is the ancient Pelasgic bonnet, shaped like a scalp, which the natives of Greece are said to have worn ever since they were known as a people. The Greeks wear it simply as a hat; the Turks surround it with a turban; and the women adorn it with a handkerchief, tassels, and fringes.

The diet of the modern Greeks, even in the higher ranks of society, is very poor and comfortless. Fowls newly killed, and therefore tough, though boiled down to rags, heaped together in a large plate, form a principal dish at dinner. The table is a low stool, and the guests are seated round it on cushions. A long, coarse, narrow towel is spread over the knees of the party at table; and the master of the house, stripping his arms bare, by turning up the sleeves of his tunic, serves out the soup and meat, tearing the poultry and butcher-meat into pieces with his fingers, which the guests eat in the same style. If knives and spoons are used, they are never changed, and one dish only is placed on the table at the same time. Brandy is handed to the company before they sit down to table, and a single glass of wine is presented to each along with the desert. During the time of dinner the room is filled with a multitude of visitors, meaner dependants, and even slaves, who do not partake of the repast, but sit and converse together behind the party at table; and after dinner an itinerant songster pushes through the crowd to a conspicuous place in the apartment, and accompanies with his lyre some miserable recitative, suited to the occasion, or some common love-ditty, repeated again and again with little melody or expression. When the meal is concluded, a maid-servant sweeps the carpet; and the master and mistress of the house, seating themselves at the upper end of the divan or couch (which is universally placed in the form of the Greek letter Π,) the rest of the company are marshalled on either side in two lines, according to the rules of precedence. When all are thus seated cross-legged, a little pewter basin is placed before each person who had partaken of the meal, and all wash their hands and mouth with a lather of soap; the same having been done also before eating. Tobacco-pipes are then brought in, and female visitants arriving, the mistress of the house retires with the women who are present, to receive these new guests in another apartment.

In the inland towns, the women live in a separate part of the house, and are nearly as much confined as those of the Turks. Before marriage, they are rarely seen by any male person, except those of their own family; but, afterwards, they are introduced to people of their own nation, or to travellers. They can seldom read or write, but are all able to embroider, and generally to play on the lute. Dancing is an universal accomplishment, and is learned from one another here in a style which displays neither elegance nor liveliness, and which chiefly consists in a solemn poising of the body on one foot, then on the other, accompanied by various elevations and depressions of the arms. But, notwithstanding their want of education, most of them are acquainted with a number of songs or recitations, accompanied with tales, which are taken up and continued, apparently without end, by different individuals of the party for hours together. Whenever they have an opportunity of making farther attainments, they discover great quickness of understanding, and readily acquire the modern languages, and the elements of general literature. Their character is described as amiable, and they make assiduous housewives and tender mothers.

The dances of the young women, particularly those called Romaica, consists in slow movements, in which they hold by each other's handkerchiefs, while one of them, as a leader, sets the step and the time. In their mixed dances, a male and female are alternately linked together, holding their handkerchiefs high over their heads, while the leader dances through them; and various figures are performed as well as single hornpipes. Single performers among the men exhibit frequently a rapid and fantastic step, which is considered as the ancient pyrrhic dance. To such amusements the natives are greatly devoted; and, "amidst all their poverty and oppression," says Sandys, "they will dance whilst their legs will bear them, and sing till they grow hoarse." There is an ancient dance, much in request, performed by boys or by girls in the harems for the entertainment of the Turks, and which is wholly of a lascivious tendency. Nay, in most parts of modern Greece, these indecent attitudes, which are esteemed as the highest accomplishment of the art, are practised by the most discreet females, without any appearance of depraved feelings on their part.

In the marriage ceremony, which is considered as still resembling the ancient usages, the bride and bridegroom stand near the altar, holding a lighted candle in their hands, while the priest, facing them, reads and sings a service, during the progress of which he takes two rings, which he puts upon their fingers, and two garlands, which he places on their heads, changing them several times with great rapidity, gabbling and singing all the time, till at last the rings are left on the proper fingers, and the garlands laid aside together. Some bread, which has been blessed and marked with the sign of the cross, is then broken and eaten by the bride and bridegroom, and a cup of wine is presented to them successively; after which the woman hands round the cake and liquor to the persons present, from whom, if she is not of high rank, she receives a piece of money, and kisses their hands in return. On the same, or sometimes the following day, she is carried in procession to her husband's house, and the evening is concluded with music, dancing, and a feast, chiefly of fruits, and particularly nuts.

The Greeks are remarkable for the formality and tediousness of their salutations. When two of them meet, however casually, they stand with their hands on their hearts, bowing gently for five minutes together, inquiring after each other's healths, their wives, daughters, sons, family, and affairs, twenty times over, before they begin to converse, or even when they are intending to separate immediately.

The modern Greeks are full of superstitious practices and unmeaning usages, many of which they have communicated to their Turkish conquerors. During the birth of a child, the lamp burns before the picture of the virgin, and the cradle is adorned with handkerchiefs and trinkets, as presents to the fairies. As soon as the infant is laid in the cradle, it is loaded with amulets: and a bit of soft mud, particularly prepared by various charms, is stuck upon the forehead, to prevent the effects of the evil eye. When a stranger looks intensely upon a child, the mother spits in its face, or in her own bosom, if he look at herself; but the sovereign remedy against the evil eye is the use of garlic, or even the pronouncing of the name of it, and bunches of it are attached to new built houses and vessels. When a person sneezes in company, the conversation is stopped, and all present pronounce benedictions on him, at the same time crossing themselves. They wear rings as spells; observe all manner of lucky and unlucky days; spit into their own bosoms upon any sudden emergency; show a peculiar veneration for salt, and practise a multitude of divining ceremonies on all occasions.

The funerals of the Greeks, like those of their ancestors, are celebrated as occasions for various entertainments, and in some respects bear a considerable resemblance to those of the lower Irish. On the death of any person of dignity, the body is dressed in a rich garment, and the litter covered with flowers. The friends and domestics, with the priests, walk in procession before the body, and a few old women, on each side of the bier, continue howling and lamenting, enumerating the virtues of the deceased, and dwelling on the many reasons which should have made him remain longer in life. Behind the body come the female relations and friends, muffled up in mourning habits. At the place of interment a funeral service is read, and the body, rolled in a winding sheet, is deposited in the grave with some of the flowers that had adorned the bier. About the ninth day after the funeral, a feast is prepared by the nearest relation, who makes presents to the priests, and entertains the guests with music, dancing, and every kind of merriment. The burying grounds are at a distance from the towns, and the churches are generally near the high road. Their groves of cypress or yew trees generally surround the tombs; and these spots are frequented on certain days by the relatives of the recent dead, who, after shedding a few tears, and depositing a garland, or lock of hair, in the grave, spend the remainder of the day in dancing and singing.

The character of the modern Greeks is variously represented; but the greater number of travellers concur in the principal features of the following portrait. Their manners are very engaging, but have rather too much the appearance of obsequiousness and insincerity. They are extremely courteous towards inferiors, and even servants; and make very little distinction in their behaviour to each other on account of rank. The rich are versatile and intriguing; the lower classes full of merriment, doing nothing at certain seasons but pipe and dance. There is still abundance of native genius among them; but in the substantial parts of character they are a degraded nation. They perform the rights of hospitality with good humour and politeness, but will take the meanest shifts to gain some pecuniary remuneration, and will do any thing for the sake of money. Though avaricious, they are not sordid, but fond of pomp and show, and profuse in their ostentation of generosity. Wealth is the only object of their admiration; whence they are almost universally engaged in trade in some form or other. The cultivation of the soil is left to Albanians or colonists; and every Greek has a retail shop, or is concerned in some wholesale dealings. Even their princes and nobles who reside at Constantinople, are engaged in merchandize. They are little to be trusted; but are light, inconstant, treacherous, selfish, and subtle, in all their transactions, always awake to every opportunity of gaining an advantage; ready to practise the meanest artifices, and to utter the grossest untruths; regardless of character, and more barefaced in their impositions than even the Jews. They show a desperate frenzy in distress, and a bloody ferocity in power, but rarely display the coolness of determined courage, and seem scarcely capable of any prolonged struggle to regain their national freedom. See Chateaubriand's *Travels;* Clarke's *Travels;* Dallaway's *Tour in the Levant;* Savary's *Letters on Greece;* Hobhouse's *Tour in Albania*, &c.; Jackson's *Reflections on the Commerce of the Mediterranean;* and the works mentioned in the historical sketch of the Morea in this article. (*q.*)

MORISON, Robert. See Botany.

MORLACHIA. See Dalmatia.

MOROCCO, or Marocco, frequently called West Barbary, is bounded on the north by the Mediterranean Sea; on the west by the Atlantic Ocean; on the south by the Sahara, or the great desert; and on the east by Tremecen, Sigelmessa, and Biledulgerid, or (according to modern and more correct orthography) Tlemsen, Segin Messa, and Bled-el-jerrede. The whole extent of this empire, including Tafilelt, is contained between 27° 40′ and 35° 40′ of N. Lat. and between 2° and 10° of W. Long. from London. It is divided into four great divisions: 1. The northern, containing the provinces of Erreef, El Garb, Benihassen, Temsena, Shawia, Tedla, and the district of Fez or Fas; 2. The central, containing the provinces of Duquella, Abda, Shedma, Haha, and the district of Morocco; 3. The southern, containing the provinces of Draha and Suse; and 4. The eastern, lying to the east of the Atlas Mountains, called Tafilelt, was formerly a separate kingdom, but became subjected to the princes of Morocco.

The principal mountains of Morocco are the Atlas Mountains, called in Arabic, Jibbel Attils, "The Mountains of Snow," the different branches of which have distinct names, according to the provinces in which they are situated. The great chain of these mountains runs through the whole extent of the empire, from Ape's Hill to Shtuka in lower Suse, passing within thirty miles of the city of Morocco, where they are of great height, and covered with snow throughout the whole year. They are visible at sea several leagues from the coast; and in a clear day may be seen at Mogadore, a distance of 140 miles. The highest peak is 12,000 feet above the level of the sea.

The rivers which rise to the east of the Atlas Mountains are the Draha, which flows through the province of the same name, from north-east to south, and disappears in the sands of the Sahara; and the Muluwra, which separates the empire of Morocco from Tremecen, flows to the northeast into the Mediterranean: both these rivers are deep and impetuous in the depth of winter, but small, and often quite dry, in summer. The other rivers, which all flow into the Atlantic Ocean, are the El kose, or Luccos, at El Araiche, which may be entered at high water by ships of 100 or 150 tons; the Baht, which partly loses itself in the lakes of the province El Garb, and partly falls into the Seboo; the Seboo, the largest river in the empire, rises to the east of the city of Fez, and falls into the sea at Meheduma or Mamora, where it is a large, deep, and navigable river; the Bu Regreg, which traverses the province of Benihassen, and discharges itself into the ocean between the towns of Salee and Rabat; the Morbeya, which rises in the Atlas Mountains, and falls into the Atlantic at the port of Azamor; the Tensift, which passes about five miles north of the city of Morocco, and reaches the ocean sixteen miles south of the town of Saffy, is chiefly remarkable for the salubrious quality of its water; the Tidsi, which falls into the sea a little south of Cape Ossem; the Suse, a fine majestic river, which joins the ocean six miles south of Santa Cruz, where its mouth is almost shut by a bar of sand, but which is supposed to have been once navigable as far as the town of Terodant; the Messa and Akassa, both of them partly navigable.

The western coast of Morocco is covered with numerous rocks, level with the surface of the water; and occasionally an extensive beach in the intermediate spaces, where the water is shallow, and the surf runs high.

There are several fresh-water lakes, particularly on the coast near the Mamora, one of which is 20 miles in length. These lakes abound with water-fowl and eels. The eels are taken and salted for sale; and, as the water is not deep, they are killed by a lance, while the fisherman sails along the surface in a slender skiff, made of the fan-palm and of rushes.

The climate of Morocco is healthy and bracing. From March to September the atmosphere is almost entirely free from clouds; and even in the rainy season from September to March, there is scarcely a day altogether without sunshine. In the province of Suse the climate is peculiarly delightful, but extremely hot in the months of June, July, and August, particularly when the Shume or hot wind blows from the desert. In the more inland districts of Draha and Tafilelt, this wind occasions intense heat in the months of July, August, and September.

The whole division north of the Morbeya is a fine champaign country, with a rich black and sometimes red soil, without stone or clay, with few trees, but remarkably productive in grain. The central provinces are equally fertile, and more abundant in pasturage.

The province of Haha, which is of great extent, is more mountainous; and that of Suse, still more extensive, is more particularly productive of the finest fruits. The more inland districts of Draha and Tafilelt are particularly fruitful in dates.

No roads are made in the country, and there are very few bridges. Except at the sea-ports, where boats are used, there is no way of passing the rivers, which are too deep to be forded, except by swimming, or on rafts. Hence, in the wet season, when the rivers are much swelled, travellers are frequently detained several days upon their banks.

Gold and silver mines are found in various parts of Morocco, particularly about Messa, in the province of Suse, and in the plains of Msegina, near Santa Cruz, which had formerly been worked by the Portuguese, but are now neglected. Gold is found also in the Atlas mountains, mixed with antimony and lead-ore; and iron, copper, and lead-ore, in Suse. At Tesellerst, near the southern frontier, the copper mines are very abundant; and in Tafilelt, the mines of antimony are of the finest quality. Immense quantities of sulphur are dug from the foot of the Atlas mountains opposite to Terodant. The salt-petre found at the same place is the purest and strongest; but it is also procured at Fez and Morocco. Mineral salt of a red colour is dug from quarries in various parts of the country; and in the province of Abda, there is an extensive lake, which furnishes a kind of salt superior to the mineral; but the purest of all is found among the rocks on many parts of the coast, where the summer sun has exhaled the salt-water in the cavities.

The principal vegetable productions of Morocco are the palm or date tree, of 30 different kinds, which is found in perfection in the southern parts of Suse, and particularly in Tafilelt; oaks, and a few other valuable trees, in the northern districts; cork trees, some of which are as large as full-grown oaks; olive-trees, which are of great size and beauty, in the southern districts, where the plantations are very extensive and productive. Various trees which yield the different kinds of gum, viz. Arabic, sandrac, ammoniac, Senegal, and euphorbium; wild juniper, which abounds in the Atlas mountains, and from which by burning a kind of pitch is extracted; various shrubs used in the preparation of leather; fig-trees which abound in every part of the empire, and produce the finest fruit; the Indian fig, or prickly pear, which grows to the height of twenty feet in the driest situations, and affords a peculiarly cooling fruit; almond trees in great abundance, particularly in Suse; apples, pears, apricots, plums, pomegranates, lemons, limes, citrons, and the most delicious oranges in the world, in the more northern provinces; grapes, melons, strawberries, and water-melons (particularly in the province of Duquella) of a prodigious size; sugar-cane, which grows spontaneously in Suse, and stick liquorice in the greatest abundance in that province; mallows and truffles; cotton of a superior quality; hemp, chiefly cultivated for the sake of its seeds and flowers, which are smoked for the purpose of intoxication; tobacco, of which the best is that of Mequinez; honey, wax, &c. The principal kinds of grain cultivated in the country are wheat and barley, peas, beans, caravances, and Indian corn; and these crops are generally so abundant, that the produce of one province, if fully raised, would suffice for the consumption of the whole empire.

The most remarkable of the animal creation in the Empire of Morocco are the horses, which are renowned for fleetness and action, particularly those of Abda, which have a stronger sinew than those of Europe, and with a little management are extremely tractable; the Keirie, or camel of the desert, which can perform in one day an ordinary three days, or seven days, or even a nine days' journey, and one of which is worth 200 camels; the horse of the desert, which lives chiefly on camel's milk, and is principally used in hunting the ostrich; mules and asses, camels and horned cattle, in all quarters; sheep of various qualities, but those of the southern provinces are remarkable for the fine flavour of their mutton, owing to the aromatic herbs on which they feed, and those of Tedla are distinguished by the fineness of their wool, which is soft as silk; goats, which are very prolific, particularly in Tafilelt, where they have young twice in the year, and some of them six kids in nine months. The principal wild beasts are lions, panthers, rhinoceroses, wild boars, hyænas, jackals, foxes, apes, antelopes, hares, squirrels, cameleons. The birds are ostriches, pelicans, eagles, flamingoes, storks, herons, bustards, wild geese, wild ducks, plovers, pigeons, wood-pigeons, turtle-doves, ring-doves, partridges, nightingales, starlings, black-birds, larks, cuckoos, owls, &c. The reptiles are lizards and serpents of various kinds, of which the most remarkable are the Boah, from 20 to 80 feet in length, and the Buskah and Effah, which are full of deadly venom. The insects most worthy of notice, are the locust, the ammoniac fly, and large loud-toned crickets. Whales have been sometimes seen on the coast of Morocco; mullet, brim, anchovies, sardines, herrings, mackarel, rock-cod, skaite, plaice, soles, turbot, turtle, and most of the fish found in the Mediterranean, are taken on the western shores of the empire, besides a fish peculiar to the coast, called izgal, which, when dried in ovens, forms a considerable article in commerce with the interior districts of Africa. The principal fresh-water fish of the country is the shebbel, similar to the salmon, a rich and delicate fish, which is dried and baked in great quantities for the use of those countries where the inhabitants live much on dates. Land-tortoises are very abundant, and of a great size. For a fuller description of the animals of the country, see Barbary.

The principal towns of Morocco are, Morocco, Mequinez, Mogadore, and Fez, (for an account of which see the respective articles under those heads,) Terodant, the old metropolis of the kingdom of Suse, an ancient and extensive town, in which there is a magnificent palace, adorned with delightful gardens, but now decreasing in population, and noted only for the manufacture of leather, saddles, dyeing of cloths, and the production of a superior kind of saltpetre. Santa Cruz, or Agadeer, the most southerly sea-port of the empire, strongly fortified by its elevated situation and numerous batteries, possessing one of the best roads for shipping, and formerly the centre of a very extensive commerce, but dismantled in the year 1773, in consequence of an attempt on the part of its governor to resist the power of the emperor Seedy Mahomet; Saffy, an ancient town, between two hills, which expose it to the torrents of winter, and increase the heat of the summer, surrounded by thick and lofty walls, possessing a road for shipping, safe in summer, but in winter exposed to violent gales, and carrying on a considerable trade in corn; El-Waladia, a small square town, situated on an extensive plain, with a very spacious harbour, capable of containing 500 sail of the line, but having its entrance obstructed by rocks; Mazagan, remarkable for its salubrious air and excellent water, which is drawn by buckets from wells 100 feet deep, and possessing also a curious subterranean cistern, constructed by the Portuguese, for collecting the rain water for the supply of the garrison; Azamore, in the province of Duquella, remarkable for the immense number of storks by which it is occupied, and which are said to exceed the number of the inhabitants; Fedala, in a delightful fruitful district, and furnished with a safe road for shipping, at all seasons; Rabat, a walled town, with docks for ship-building, and a manufactory of cotton cloth, but chiefly remarkable for the ruins of a magnificent mosque, of which the roof was supported by 360 marble columns, and for a subterranean cistern, the tower of which, above 180 feet high, has so gradual an ascent to the top, made of a mixture of lime and sand, that a man on horseback may ride to the summit; Sallee, on the opposite side of the river to Rabat, which is also a walled town, defended by batteries, and formerly had a harbour capable of admitting large vessels, but is now greatly obstructed by the accumulation of sand at the entrance of the river; Mamora, or Maheduma, now a deserted place, partly on account of the swarms of annoying insects by which it is infested, and chiefly occupied by fishermen, who take incredible quantities of a species of salmon, called shebbel, for the supply of the interior; Larache, or El Araiche, in a rich and beautiful tract, where the gardens of the Hesperides are supposed to have been situated, and formerly a place of considerable commerce, but since 1780 almost totally evacuated, by the orders of the emperor; Tangier, or Tinjiah, which was given by the crown of Portugal, in 1662, as a marriage portion, with the Princess Catherine, to Charles II. of England, but abandoned by the English in 1684, after they had demolished the fortifications, a place which has few productions in its vicinity for the purposes of commerce, but is still a favourable station for Moorish pirates; Ceuta, or Cibta, supposed to be of Carthaginian origin, and formerly the metropolis of the countries held by the Goths in Hispania Transfretana, now possessed by the Spaniards, though often besieged by the Mahommedans; Tetuan, or Tetawan, situated in a country which produces the finest fruits, particularly oranges, and which carries on a considerable trade in provisions with Gibraltar, but in which no Europeans are allowed to settle since the year 1770, in consequence of a Moor having been shot by an Englishman; Velis, or Bedis, situated between two mountains, and surrounded with excellent timber; and Melilla, a place celebrated for the best wax and honey, and which has been in the possession of the Spaniards since the beginning of the 16th century.

The government of Morocco is the most unlimited despotism, both in theory and practice. There are really no other laws than the will of the emperor, whose mandates must be obeyed, even though they should deviate from the principles enjoined by the Koran. He administers justice in person, where he resides, and hears all complaints in the hall of audience, generally twice, and sometimes four times a week. Every individual, of whatever country, sex, or station, has free access to his presence, and full permission to state his cause. Every applicant brings a present suited to his condition; and the smallest matter, even a few eggs, will be accepted. Judgment between the parties is always prompt, and considered as generally correct, unless where wealth has interposed to bribe the judge. In other places, remote from the court, the vice-regent or hashaw administers justice in like manner, according to the laws of the Koran, or as his own caprice may direct. All subaltern magistrates proceed in the same despotic manner, often using the authority of the emperor to enforce their exactions; and all of them having no other object than to extort money from any individual who is known to possess property to a considerable amount. Emissaries and spies are continually at work to discover the persons who have any treasures in their possession, and to find out grounds of accusation against them. These very extortioners are in their turn exposed to the same treatment from the emperor, who sends some unexpected order, accusing them of crimes and misdemeanors, and demanding their accumulated wealth for the imperial treasury. In every province is a governor, named a bashaw, who is appointed and removed at the will of the emperor; in every douar, or Arab encampment, a similar officer of government, called a sheik; and in every town another, called alcaid; each possessing, in their respective districts, equally unlimited power with the sovereign, except that their decision may be carried by appeal before the emperor. Under the alcaid is an officer named el-haikum, or deputy governor, and another denominated cadi, who acts both as a priest and a civil judge, and in whose absence any of the talbs or common priests is authorized to discharge the office.

Trifling offences are usually punished by the bastinado, or beating the back and legs with leather straps, which is sometimes executed with great severity. In greater crimes, particularly theft, the hands are cut off, or a leg or hand. Persons capitally punished are sometimes shot, run through the body with swords, knocked down with clubs, or beheaded. A peculiar mode of punishing offenders is tossing, which is so managed that the sufferer falls immediately upon his head; and there are executioners so expert at this practice, that they can throw persons up, so as at pleasure to break the head, dislocate the neck, fracture a leg or arm, or let them fall without any material injury. But almost every mode of cruelty is occasionally practised in this miserable country. These punishments are usually superintended by the emperor in person, and used formerly to be frequently inflicted by his own hand, but now are generally executed by some of the negro soldiers.

The principal officers of the court are, the effendi, or friend, who is the prime minister and responsible person in the state; the secretary to the treasury, (united with the office of the effendi,) who disburses the payments of the emperor, has several under secretaries; the master of the horse, with 120 assistants; the grand-chamberlain, with 17 assistants; and grand-falconer, (a hereditary office) with 20 assistants; the keeper of the great seal; two grand-stewards; five inspectors-general of all the emperor's affairs, of whom the effendi is the chief; three masters of ceremonies for public audiences, with 40 assistants; an interpreter-general for European languages, who is usually a renegado; two grand-keepers of the jewels and plate; a grand-master of the baths; two grand-keepers of the arsenal; two keepers of the emperor's goods and warehouses; three inspectors of mosques, &c.; five keepers of the provisions; two keepers of the library; two astrologers; four masters of the carriages; twelve sons of renegadoes, who have not had beards, employed in drawing the small carriages; three principal assistants for prayers, with several deputies; three bearers of the umbrella, with their assistants; the bearer of the sabre; two bearers of the basin; two bearers of the lance; the bearer of the watch; five bearers of the emperor's firelocks, with their assistants; the bearer of the standard; a physician and surgeon, with many kinds of tradesmen. All these officers receive no salaries from the emperor, but depend entirely on the perquisites which are paid to them by those who transact any business with the court; and even what they receive in this way is often liable to be seized by the sovereign, unless he be gratified by occasional presents.

The Harem forms a part of the palace, and communicates with it by a private door, used only by the emperor. The apartments are also on the ground-floor, square, and very lofty; and four of them enclose a spacious square area, into which they open by means of large folding doors, which serve the purpose also of windows. These areas, or courts, are floored with blue and white chequered tiling, and have a fountain in the centre, supplied by pipes from a large reservoir on the outside of the palace. Twelve of these courts, communicating with each other by narrow passages, form the harem; and the women whom it contains have free access to every part of it. The apartments are adorned externally with beautifully carved wood-work; and are generally hung on the inside with red damask, of various colours, and furnished with beautiful carpets on the floors, and mattresses in different places, for the purposes of sitting and sleeping. At each end is placed, merely by way of ornament, an elegant European mahogany bedstead, hung with damask, and covered with mattresses of various coloured silks; and large looking-glasses, clocks, and watches in glass cases, are hung around the walls. The sultana is called the mistress of the harem, but without any control over the other females; and she has a whole square for her own use, while each of the rest has only one apartment. Each female has a separate daily allowance from the emperor, according to the rank which they hold in his estimation, out of which she is expected to furnish herself with whatever she requires. This allowance, at the time of Lempriere's visit to the emperor of Morocco, was little more than half a crown sterling to the favourite sultana, and less in proportion to the others; but the emperor makes them occasional presents of money, dress, and trinkets; and they receive considerable sums from those who solicit their influence in obtaining favours from the court. In this way ambassadors, consuls, merchants, native or foreign, are most assured of gaining their object with the sovereign, who rather encourages negotiations through this channel. These females are never permitted to go out of the harem, unless by an order from the emperor; and, except an occasional walk within the bounds of the palace, or a journey from one palace to another, they are constantly immured within their prison. Four of these women are considered as wives of the emperor, and the rest as concubines. Many of these are Moorish women, as the Moors consider it an honour to have their daughters in the harem; some of them European slaves; several are negresses, and the usual number of the whole is from 60 to 100, besides their slaves and domestics. Priestesses, who are so far learned as to read and write, are employed to teach the younger part of the harem to repeat their prayers, and to instruct the older females in the principles of their religion. The inhabitants of the harem are seldom observed at any other employment, except forming themselves into circles for conversation, or hearing stories, bathing, dressing themselves, and perhaps working a little at the needle. The sons of the emperor's wives are considered as princes, who have an equal claim to the empire; and they are generally appointed to the government of some of the provinces, as bashaws. But the daughters and the children of the concubines are generally sent at a proper age to the city of Tafilelt (the inhabitants of which are all sharifs, or supposed descendants of Mahommed) where they finish their education and intimacy with their kindred in the place. It is the peculiar privilege of the imperial family, that is, of the emperor himself, his sons, and brothers, to have the benefit of umbrellas; the shade of which, in a climate like that of Morocco, is one of the greatest luxuries.

The revenue of the emperor consists of a tenth upon every article of consumption, as allowed by the Koran; an annual tax upon the Jews; custom-house and excise duties; tributes exacted from his own subjects, foreign states, and European merchants, in the form of presents; which last articles form the chief source of his income. The duties and tributes are so frequently changed that it is impossible to estimate their annual amount with any degree of certainty.

The army used to consist principally of black troops, the descendants of negroes imported from Guinea, amounting altogether to above 40,000, and sometimes even 100,000 men; of whom two-thirds are cavalry; but every man is considered as a soldier, and obliged to act in that capacity, whenever the emperor shall require his services. The present emperor, Muley Solyman, has diminished the proportion of black troops; but negroes are still employed as governors of cities, commanders of the body guard, eunuchs in the harem, and in other offices of state. About 6,000 of the standing army, form the emperor's body guard; and the rest are quartered in the different towns of the empire, under the bashaws of the provinces. The soldiery are clothed by the emperor, and receive a little pay, but depend chiefly upon plunder. They are distinguished from the other Moors only by their accoutrements, which consist of a long musket, a sabre, a small red leather box to hold their balls, and a powder horn slung over their shoulders. The army is under the direction of a commander-in-chief, some principal bashaws, and officers of divisions called Alcaides. They have little order and regularity in their manœuvres, and are more like a rabble than an army.

The Navy consists of about 20 small frigates, a few xebecks, and 30 row galleys. The number of seamen in the service is computed at 6,000; the whole commanded by one admiral; but, being chiefly used in piracy, they are seldom united as a fleet. The naval power of the empire is altogether contemptible; and the whole maritime department becoming every year less effective, from the filling up of the harbours by sand, and other causes of their demolition.

The sea-port towns of Morocco carry on a very limited commerce with foreign nations. European factories have been established in some of them at different times; but have been often abandoned altogether, on account of the continually varying orders of the emperors, relating to trade and other matters; and partly on account of the unwillingness of Europeans to transmit merchandise to a country where there is so little security for property. The European merchant has so many difficulties in recovering debts due to him by the natives, that credit is in a great measure annihilated, and the trade of Morocco is, in a manner, transformed into barter. The principal commercial place in the empire, is the port of Mogadore; into which are imported cloths, linens, muslins, damasks, raw silk, copperas, tea, sugar, iron, and iron nails, hardware, pewter, spices, copper, thread, mirrors, earthen-ware, knives, brass pans, glass, Mexico dollars; and from which are exported almonds, gums, bees-wax, oil of olives, goat-skins, hides, wool, feathers, elephant's teeth, drugs, tallow, leather, raisins. At this place

The annual value of imports has been	151,450*l.*
The annual value of exports .	127,679*l.*

This trade is obviously of a valuable description to Europe, as it carries off manufactured goods of all kinds, and furnishes useful raw materials in return; and might be considerably augmented for the interest of Great Britain, by the establishment of well qualified persons as consuls, to establish friendly treaties, and to serve as the authorized channels of communication with the Moorish government.

There are large weekly markets held in the metropolis, where all articles of foreign and home manufacture are bought and sold. At these times, samples of the different kinds of merchandize are carried up and down the streets by itinerant auctioneers, who proclaim the price offered, and who apprize the highest bidder of his purchase; to whom the article is delivered upon his paying the money, and the transaction terminates. A considerable trade is carried on between the principal cities of Morocco and Timbuctoo, by means of large caravans, which cross the great desert; and which usually complete their journey from Fez to Timbuctoo in the space of 129 days. The principal articles which they carry out, are German and Irish linens, muslins, cambrics, fine cloths, raw-silks, beads, brass nails, tea, sugar, spices, tobacco, salt, red woollen caps, sashes, shawls, and haiks of silk and gold, manufactured in Fez and Tafilelt They bring back gold in dust, rings and bars, elephant's teeth, gums of various kinds, and slaves; besides ostrich feathers, and ambergris collected on the confines of the desert.

The religion of the empire of Morocco is Mahommedism; but toleration is granted in some measure to any sect which does not admit a plurality of gods; and, on proper application, they are permitted to appropriate a place for public worship. There are Catholic establishments in Morocco, Mequinez, Mogadore, and Tangier. Through all the country, there are buildings of an octagonal form, called Zawiat, or Sanctuaries, with an uninclosed piece of ground attached to each, for the interment of the dead. In these places is a priest or saint, who superintends divine service, and the burial of the dead, and who is often applied to as arbiter in disputes. In these consecrated places, the wealthy inhabitants often deposit their treasures for security; and criminals find protection against the hand of justice. The other religious institutions of the empire, are so similar to those of other Mahommedan countries, as to render a separate account of them altogether superfluous.

The estimates given by different travellers of the population of the empire, are so irreconcileable with one another, that it is impossible to speak on the subject with any degree of certainty. The whole inhabitants of Morocco have been calculated at two, at six, and at fifteen millions. The last is the statement of Mr. Jackson, who made his extracts from the imperial register. The city of Morocco contains, or did recently contain,

According to Jardine . . .	20,000
Jackson . .	270,000
Doctor Buffa, . .	650,000
And Fez contains,	
According to Jardine . . .	30,000
Ali Bey, . . .	100,000
Jackson, . . .	380,000

The population of the empire of Morocco, is principally composed of two great original classes, the Berebbers, and the Arabs.

The Berebbers are the descendants of the original inhabitants of the country before the Arabian conquest; and occupy all the mountainous districts. Though they have acknowledged the authority of the Koran, they have tenaciously maintained their independence, and carry on a desultory warfare against their Mahommedan invaders. They are an athletic, hardy, and enterprising race, with regular, and sometimes handsome features, but remarkable for the ferocious expression of their eye. They are characterised by a peculiar scantiness of beard; and, in the southern districts, many of them have only a few straggling hairs on the upper lip, with a small tuft on the chin. Their whole dress consists of a woollen jacket without sleeves, and a pair of trowsers. They dwell in caves, mud huts, or hovels of stone and timber, which are generally situated on some commanding eminence, and frequently surrounded with walls furnished with loop-holes for musquetry. They cultivate the ground, and feed cattle; but are almost universally robbers; and fall without mercy upon all travellers, who have not purchased a protection from some of their chiefs. They are divided into a number of petty tribes, distinguished by the names of their respective patriarchs and founders, and speak a variety of dialects, quite distinct from the Roman and Arabic languages. The great subdivisions of this class of natives are the Errifi, who inhabit the extensive mountainous province of that name, on the shores of the Mediterranean, and who are the most athletic, ferocious and faithless of them all; the Berebbers of the interior, who occupy the highlands from the southern confines of Errif, to the vicinity of Fez and Mequinez, and who are similar to the former in person, but less savage in their disposition; the Berebbers of Middle Atlas, who resemble the last mentioned in most respects; and the Berebbers of south Barbary, who extend from Mogadore southwards, and from the eastern limits of Atlas to the sea coast—who are also called Shilluks. These last, who are sometimes described as a distinct race, are more diminutive in person than those of the north, and have, in general, also an effeminate tone of voice. They have more of the social qualities; and are more faithful in observing the promises of protection granted by their chiefs.

The Arabs, who are the direct descendants of the invaders of the country, compose the most numerous class of the population, and are scattered over the whole level districts of northern Africa, even to the confines of the Great Desert. They are generally tall and robust, with fine features, and countenances full of intelligence, their eyes large, black and piercing, their noses gently arched, their teeth white and regular, their beards full and bushy, their hair strong, straight, and universally black, their skin, in the northern parts, of a bright, clear, brown colour, gradually darkening to black, as they approach towards the south. They are all cultivators of the earth, and breeders of cattle, depending entirely on agricultural pursuits for subsistence. They dislike the restraints of cities, and dwell invariably in tents, in families that vary in number from ten to a hundred. Each of their tribes has its own chief or sheik, who explains the Koran, and administers justice; and in the centre of each encampment is a tent, appropriated for religious worship and the reception of travellers. They move from place to place as the pasturage fails, or the land becomes exhausted; and separate into different parties, as their number and flocks may require. On their march, the women are placed on the backs of the camels, the children and lambs in the panniers on each side; and the fowls instinctively perch upon the baggage. Part of the men on horseback are armed with muskets, and act as a guard to the party, while the rest drive along the herds. They are more violent, but less treacherous than the other classes; faithful to the laws of hospitality within the limits of their encampment, but ready to murder the last night's guest when they meet him again beyond these boundaries. They are perpetually engaged in war with one another, with the Berebbers, or with the troops of the sovereign, who are sent out to collect the taxes, and they carry on their hostilities with the most savage brutality; sometimes ripping up the dead bodies of their victims, to discover the riches which they suspect them to have swallowed for the purpose of concealment.

The Moors, a name used only by Europeans, are the inhabitants of the towns, whom the Arabs call Medainien, or towns people, and who call themselves Mooslim, or believers. They are a mixture of all the nations who have at any time settled in Northern Africa, and are subdivided into four classes: 1. Those descended from Arab families, who form the larger part of the population in the southern towns, and of those which border on Arab districts; 2. Those who are sprung from the Berebbers, who are more or less numerous in the towns, according to the proximity of the Berebber districts; 3. The Bukharie or black tribe, who are the descendants of the negroes who have been brought as soldiers into the country, and who are most numerous in Mequinez; and, 4. the Andalusie, the reputed descendants of the Arab conquerors of Spain, who form a large class in the towns of the north of Barbary, and are seldom seen to the south of the river Asa Moor. The two former classes distinguish themselves by the name of the tribes from which they have sprung, and keep up a close alliance with their kindred families in the country; but the two latter denominations are entire in themselves, as two distinct communities. The Moors are an indolent and taciturn race, jealous, deceitful, and cruel, losing even the natural affections in their extreme selfishness, and altogether degraded by the influence of their absurd religion, their gross ignorance, and their wretched government. The reader is referred to the Article Barbary for an account of the manners and customs of the inhabitants. See Chenier's *Present State of Morocco.* Lempriere's *Tour to Morocco;* Jackson's *Account of the Empire of Morocco; Narrative of* Adams, *a Sailor, with appendix* by Mr. Dupuis; Ali Bey's *Travels;* Keatinge's *Travels in Europe and Africa.* (*q.*)

MOROCCO, a city of West Barbary, and the metropolis of the empire of Morocco, is situated in the midst of a beautiful valley, formed by a chain of mountains on the north, and those of the Atlas on the south and east The country which immediately surrounds it is a fertile plain, diversified by clumps of shrubs and palm trees, and watered by numerous streams which descend from the Atlas mountains. About five miles from the city towards the south, are seen the emperor's gardens, and large inclosed olive plantations, which greatly increase the beauty of the surrounding scenery. The city was founded in A. D. 1052, by an Arab chief named Jusuf Teshfin, and is said to have encreased so rapidly, that, in the time of his grandson, it contained a million of inhabitants. Leo Africanus speaks of it as one of the largest cities in the world; but the extent of ground which it covered, (which is ascertained by the ancient walls which still exist, and which are only 7 or 8 miles in circuit,) contradicts the probability of its having ever contained so great a population. At present its inhabitants do not exceed 30,000; and many of its most magnificent buildings are in a state of ruin and decay. The walls are extremely thick, and are built of a cement of lime and sandy earth, called by the Moors tabbia, which is put into cases, and beaten together with square rammers. These walls are flanked by square towers, and surrounded by a wide and deep ditch. There are numerous entrances, consisting of large double portions, built of tabbia in the gothic style, the gates of which are regularly shut every night at certain hours. The streets are very narrow, dirty, and irregular; and the best houses are built in the midst of the gardens behind high walls of the rudest construction, as every proprietor is anxious to conceal his wealth from the eye of the public. Most of them, also, are constructed like forts for defence, and approached by a narrow lane, capable of admitting only a single horseman at a time. There are many temples or mosques in the city, but few of them remarkable for magnificence. One of them, which has a cistern under it for collecting water in the rainy season, has its central space supported by pillars of marble, and has a lofty square tower, with a winding terrace reaching to the top, from which Cape Cantin, distant about 120 miles, is distinctly visible. Another tower is remarkable from the circumstance of its having three golden balls on its top, weighing together, it is said, 10 quintals, or 1205 lbs. avoirdupois, which several kings, when in want of money, have in vain attempted to take down. The imperial palace, which faces mount Atlas, is built of hewn stone, ornamented with marble. The architecture of the principal gates is Gothic, embellished with various ornaments in the Arabesque style. The walls of some of the rooms are of fillagree work, and others of glazed tiles, which are fixed in the walls with much art, and which have a cooling effect. There are three gardens attached to the palace, abounding in the richest fruits and most fragrant flowers. In these gardens are irregular square buildings called pavillions, with pyramidal roofs, covered with glazed tiles of various colours, lighted by four lofty doors, and painted and gilt in the Arabesque style. In these pavillions the emperor takes coffee or tea, and transacts business with the officers of his court. They seldom contain any other furniture than a couple of sofas, some china and tea equipage, a clock, a water-pot, a few arms hung round the walls, and carpets to kneel upon in prayers. Near the palace is the place of audience, an extensive quadrangle, walled round, but open above, in which the emperor gives audience to his subjects, and administers justice. The Kasseria, a place of trade, is an oblong building, surrounded with small shops, filled with silks, cloths, and other valuable articles. These shops, like those of other towns in Morocco, are nothing more than openings in the walls about a yard from the ground. and just of sufficient height to admit a man to sit within them cross-legged, with the goods and drawers so arranged round him, that he can serve his customers, who stand in the street, without needing to move from his seat. At the extremity of the city, towards the Atlas mountains and near to the imperial palace, is the district occupied by the Jews, which forms a separate town of itself, with an alcaide appointed by the the emperor, to give them protection, and the gates of which are shut and opened at certain hours; but not much above 2000 Jews now reside in the place, as most of them prefer a dwelling in the adjacent mountains, where they are free from oppression and insult. In this quarter stands the Spanish convent, which used to be occupied by a few friars. but is now deserted. There is an ancient subterraneous aqueduct built of brick, twenty feet below the surface, which goes round the town, and from which pipes of brick work branch off at every hundred yards, to convey the water into the houses. But this aqueduct is much neglected, and the city is supplied with water by wooden pipes from numerous wells in the adjoining olive plantations. The wealthier inhabitants procure water from the river Tensift, which flows at a short distance from the city, and the water of which is accounted very salubrious, and particularly medicinal in cases of indigestion. Many of the streets are filled with the ruins of old houses, and in the Jew's quarter, the heaps of dung are as high as the houses. The houses are also greatly infested with vermin, particularly with bugs, which, in the summer season, literally cover the walls. The air around the city is generally calm, and the climate healthy, as the neighbouring mountains of Atlas, which are always covered with snow, serve at once to cool the surrounding atmosphere, and to furnish a shelter from the scorching winds of the desert. W. Long. 7°. North Lat. 30° 57′. (*q*.)

MORPETH, is the name of a market and borough town of England, in the county of Northumberland. The town is situated among woody undulating hills, on the great north road from Edinburgh to London, on the banks of the river Wensbeck, which is crossed by a stone-bridge. It consists principally of one long street, which is spacious, and contains many well-built and neat houses. The principal buildings are the parish church, which is built on Kirk Hill, a quarter of a mile from the town; a handsome town-house, built by the Earl of Carlisle in 1714, from a design of Vanburgh; the county gaol, which stands near the bridge, and is well built and well managed. The charitable establishments are a free school, founded by Edward VI. and an hospital for old persons. The principal piece of antiquity here is the castle, which stands on an eminence above the town. A part of the gateway, tower, and fragments of the outward wall, only remain. On the north side of the castle is a round mound of earth, which was probably a malvoisin in some blockade. A fragment of the door-way of the New Minster Abbey of White Monks still remains. Morpeth sends two members to parliament, and the right of election is vested in about 200 burgesses. The population of Morpeth, in 1811, was

Inhabited houses	464
Number of families	832
Ditto employed in trade	529
Total population	3244

See the *Beauties of England and Wales*, vol. xii. p. 183.

MORRIS (Robert). The life of an individual who, for a long period, held a prominent station in society, and rendered important services to this country, deserves particular notice in a work of this nature. The writer regrets that the short time allowed him to furnish it, will render the account brief.

Robert Morris was the son of a respectable merchant of Liverpool, England, who had for some years been extensively concerned in the American trade; and while a boy, was brought by his father to this country, in which it appears he intended to settle. During the time that the subject of this sketch was pursuing his education in Philadelphia, he unfortunately lost his father, in consequence of a wound received from the wad of a gun, which was discharged as a compliment by the captain of a ship consigned to him, that had just arrived at Oxford, the place of his residence, on the eastern shore of the Chesapeake Bay; and was thus left an orphan at the age of fifteen years. In conformity to the intentions of his parent, he was bred to commerce, and served a regular apprenticeship in the counting-house of the late Mr. Charles Willing, at that time one of the first merchants of Philadelphia. A year or two after the expiration of the term for which he had engaged himself, he entered into partnership with Mr. Thomas Willing. This connection, which was formed in 1754, continued for the long period of thirty-nine years, not having been dissolved until 1793. Previously to the commencement of the American war, it was, without doubt, more extensively engaged in commerce, than any other house in Philadelphia.

Of the events of his youth we know little. The fact just mentioned proves, that although early deprived of the benefit of parental counsel, he acted with fidelity, and gained the good will of a discerning master. The following anecdote will show his early activity in business, and anxiety to promote the interests of his friend. During the absence of Mr. Willing at his country place near Frankford, a vessel arrived at Philadelphia, either consigned to him, or that brought letters, giving intelligence of the sudden rise in the price of flour at the port she left. Mr. Morris instantly engaged all that he could contract for, on account of Mr. Willing, who, on his return to the city next day, had to defend his young friend from the complaints of some merchants, that he had raised the price of flour. An appeal, however, from Mr. Willing to their own probable line of conduct, in case of their having first received the news, silenced their complaints.

Few men in the American colonies were more alive to the gradual encroachment of the British government upon the liberties of the people, and none more ready to remonstrate against them, than Mr. Morris. His signature on the part of his mercantile-house firm to the non-importation agreement, as repected England, which was entered into by the merchants of Philadelphia in the year 1765, while it evinced the consistency of his principles and conduct, at the same time was expressive of a willingness to unite with them in showing their determination to prefer a sacrifice of private interest to the continuance of an intercourse, which would add to the revenue of the government that oppressed them. The extensive mercantile concerns with England of Mr. Morris's house, and the large importations of her manufactures and colonial produce by it, must have made this sacrifice considerable. His uniform conduct on the subject of the relative connexion between England and the Colonies, his high standing in society, and general intelligence, naturally pointed him out as a fit representative of Pennsylvania in the national councils, assembled on the approach of the political storm; and he was accordingly appointed by the legislature of Pennsylvania, in November 1775, one of the delegates to the second congress that met at Philadelphia. A few weeks after he had taken his seat, he was added to the secret committee of that body, which had been formed by a resolve of the preceding congress (1775,) and whose duty it was "to contract for the importation of arms, ammunition, sulphur, and saltpetre, and to export produce on the public account to pay for the same." He was also appointed a member of the committee for fitting out a naval armament, and specially commissioned to negotiate bills of exchange for congress; to borrow money for the marine committee, and to manage the fiscal concerns of congress upon other occasions. Independently of his enthusiastic zeal in the cause of his country, his capacity for business, and knowledge of the subjects committed to him, or his talents for managing pecuniary concerns, he was particularly fitted for such services; as the commercial credit he had established among his fellow citizens probably stood higher than that of any other man in the community, and this he did not hesitate to avail himself of, whenever the public necessities required such an evidence of his patriotism. These occasions were neither few nor trifling. One of the few remaining prominent men of the revolution, and who filled an important and most confidential station in the department of war, bears testimony that Mr. Morris frequently obtained pecuniary and other supplies, which were most pressingly required for the service, on his own responsibility, and apparently upon his own account, when, from the known state of the public treasury, they could not have been procured for the government. Among other facts in point may be mentioned, the prompt and fortunate supply of cash which he was enabled to furnish the commander in chief, while he lay on the Delaware with the army, opposite to Trenton, (December, 1776,) and which he had written for, as essentially necessary to enable him to obtain such intelligence of the movement and position of the enemy, as would authorize him to act offensively. The requisite sum was obtained from a member of the society of Friends, upon the written obligation of Mr. Morris; and this timely compliance with the demand, enabled general Washington to make the attack, and gain the signal victory at Trenton over the savage Hessians; a victory which, exclusively of the benefits derived from its diminishing the numerical force of the enemy by nearly one thousand, was signally important in its influence, by encouraging the patriots, by checking the hopes of the enemies of our cause, and by destroying the impression which the reputed prowess of the conquered foe, and the experience of their ferocity over the unprotected and defenceless, had made upon the people. Upon another occasion, he became responsible for a quantity of lead, which had been most urgently required for the army, and which most providentially arrived at the time when greatly wanted. At a more advanced stage of the war, when pressing distress in the army had driven congress and the commander in chief almost to desperation, and a part of the troops to mutiny, he supplied the army with four or five thousand barrels of flour, upon his own private credit; and, on a promise to that effect, persuaded a member to withdraw an intended motion to sanction a procedure which, although common in Europe, would have had a very injurious effect upon the cause of the country: this was no less than to authorize general Washington to seize all the provision that could be found within a circle of twenty miles of his camp.* While financier, his notes constituted, for large transactions, part of the circulating medium. Many other similar instances occurred of this patriotic interposition of his own personal responsibility for supplies, which could not otherwise have been obtained.

In the first year in which he served as a representative in congress, he signed the memorable parchment containing the declaration that for ever separated us from England, and thus pledged himself to join heart and hand with the destinies of his country, while some of his colleagues, who possessed less firmness, drew back and retired from the contest. He was thrice successively elected to congress, in 1776, '77, and '78.

The exertion of his talents in the public councils, the use of his credit in procuring supplies at home, of his personal labour as special agent, or congressional committee-man, and of those in his pay, in procuring others from abroad, were not the only means employed by him in aiding the cause in which he had embarked. The free and public expression of his sentiments upon all occasions, in the almost daily and nightly meetings of the zealous; in the interchange of friendly intercourse with his fellow citizens, and the confident tone of ultimate success which he supported, served to rouse the desponding, to fix the wavering, and confirm the brave. Besides, the extensive commercial and private correspondence which he maintained with England, furnished him with early intelligence of all the public measures resolved on by the British government, the debates in parliament, and with much private information of importance to this country. These letters he read to a few select mercantile friends, who regularly met in the insurance room at the Merchants' Coffee-house, and through them the intelligence they contained was diffused among the citizens, and thus kept alive the spirit of opposition, made them acquainted with the gradual progress of hostile movements, and convinced them how little was to be expected from the government in respect to the alleviation of the oppression and hardships against which the colonies had for a long time most humbly, earnestly, and eloquently remonstrated. This practice, which began previously to the suspension of the intercourse between the two countries, he continued during the war: and through the route of the continent, especially France and Holland, he received for a time the despatches which had formerly come direct from England.

The increasing and clamorous wants of the army, particularly for provisions, and the alarming letter written by the commander in chief to congress on the subject, on being communicated to Mr. Morris, induced him to propose to raise an immediate fund to purchase supplies, by

* Debates on the renewal of the charter of the Bank of North America, p. 47. Philadelphia, 1786.

the formation of a paper-money bank; and to establish confidence in it with the public, he also proposed a subscription among the citizens in the form of bonds, obliging them to pay, if it should become necessary, in gold and silver, the amounts annexed to their names, to fulfil the engagements of the bank. Mr. Morris headed the list with a subscription of 10,000*l.*; others followed, to the amount of 300,000*l.* The directors were authorized to borrow money on the credit of the bank, and to grant special notes, bearing interest at six per cent. The credit thus given to the bank effected the object intended, and the institution was continued until the Bank of North America went into operation, in the succeeding year.* It was probably on this occasion, that he purchased the four or five thousand barrels of flour above mentioned, on his own credit, for the army, before the funds could be collected to pay for it.†

If the grand, and as regarded the fate of the union, the decisive measure of the attack on Cornwallis, did not originate with Mr. Morris, as the facts communicated to the writer induce him to believe; there can be no doubt of his warmly approving it, that he first proposed it to the commander in chief, and provided the funds to enable general Washington to move the army. At that time, the American army lay at New-Windsor, waiting for the French fleet and troops from the West Indies, to co operate with them in an intended attack on New-York; but count De Grasse, the French admiral, changed the destination of his squadron, and went into the Chesapeake. The serious nature of the proposed operation in the south, and his total inability, from the want of funds, to move the army, induced general Washington to hesitate in giving his assent to the proposition; but the promise of Mr. Morris to supply the necessary means, overcame his scruples, and the first intelligence congress had of the movement, was the march of the troops, on the third of September, through Philadelphia. It was not, however, until the army had passed the city 15 miles, that he was relieved from his anxiety respecting his promise to general Washington of a competent pecuniary supply. His object, for this end, was the loan of the French military chest, and the proposition was made to the French minister Luzerne, who refused in the most positive manner to assent. His persuasive talents succeeded with count Rochambeau, and at Chester, whither Mr. Morris repaired, it was obtained. It is probable that the joy naturally felt on meeting at that place an express from the marquis Fayette, announcing the arrival of count De Grasse in the Chesapeake, with an assurance from Mr. Morris that our army could not move without funds, contributed to the obtaining this fortunate loan.

In the year 1781, Mr. Morris was appointed by congress "superintendant of finance," an office then for the first time established. This appointment was unanimous. Indeed, it is highly probable, that no other man in the country would have been competent to the task of managing such great concerns as it involved, or possessed, like himself, the happy expedient of raising supplies, or deservedly enjoyed more, if equal public confidence among his fellow citizens, for punctuality in the fulfilment of his engagements. As the establishment of the office of finance, and the appointment of Mr. Morris to fill it, formed an epoch in the history of the United States, and in the life of that officer, it merits particular notice.

It is well known that the want of a sufficient quantity of the precious metals in the country, for a circulating medium, and the absolute necessity of some substitute to carry on the war, induced congress, from time to time, to issue paper bills of credit to an immense amount. For a time, the enthusiastic zeal and public spirit of the people induced them to receive these bills as equal to gold and silver; but, as they were not convertible into solid cash at will, and no fund was provided for their redemption, depreciation naturally followed, as a necessary result, and with it public credit. "In the beginning of the year 1781, the treasury was more than two millions and a half in arrears, and the greater part of the debt was of such a nature, that the payment could not be avoided, nor even delayed: and therefore Dr. Franklin, then our minister in France, was under the necessity of ordering back from Amsterdam monies which had been sent thither for the purpose of being shipped to America. If he had not taken this step, the bills of exchange drawn by order of congress must have been protested," and a vital stab thereby given to the credit of the government in Europe. At home, the greatest public as well as private distress existed; "public credit had gone to wreck, and the enemy built their most sanguine hopes of overcoming us upon this circumstance:"‡ and "the treasury was so much in arrears to the servants in the public offices, that many of them could not, without payment, perform their duties, but must have gone to gaol for debts they had contracted to enable them to live." To so low an ebb was the public treasury reduced, that some of the members of the board of war declared to Mr. Morris, they had not the means of sending an express to the army.§ The pressing distress for provision among the troops at the time, has already been mentioned. The paper bills of credit were sunk so low in value, as to require a burthensome mass of them to pay for an article of clothing. But the face of things was soon changed. One of the first good effects perceived, was the *appreciation*‖ of the paper money; "this was raised from the low state of six for one, to that of two for one, and it would have been brought nearly, if not entirely to par, had not some measures intervened, which, though well meant, were not judicious." The plan he adopted was, "to make all his negotiations by selling bills of exchange for paper money, and afterwards paying it at a smaller rate of depreciation than that by which it was received; and at each successive operation the rate was lowered, by accepting it on the same terms for new bills of exchange, at which it had been previously paid. It was never applied to the purchase of specific supplies, because it had been checked in the progress towards par, and therefore, if it had been paid out in any quantity from the treasury, those who received it would have suffered by the consequent depreciation."

A minute's reflection will show the arduous nature of the duties he undertook to discharge.

In old organized governments, where a regular routine of a department has been long established, and the

* Of ninety-six subscribers who gave their bonds, six only are alive, viz. Charles Thompson, Richard Peters, Thomas Leiper, Wm. Hall, John Donaldson, and John Mease. For the original list, and account of the bank, see the Pennsylvania Packet for June, 1781.

† Debates on the Bank of North America, p. 47.

‡ Mr. Morris's Debates on the Bank, p. 49.

§ Debate on the renewal of the charter of the Bank of North America, p. 47.

‖ This word appears to have been coined during the revolution, and used as the opposite of *depreciation.*

details, as it were, brought to perfection, by gradual improvement, derived from the experience and talents of successive officers, little difficulty is experienced by the new incumbent in continuing the customary train of operations. Simple honesty, attention to duty, and a careful progress in the path previously pointed out, are all the requisites; but the state of public affairs, and especially in the fiscal department of the United States at the time alluded to, furnished none of these helps. Every thing was in the greatest confusion; and a new system of accounts was not only required to be devised, but the means of supplying the numerous and pressing wants of the public service to be discovered, and those wants attended to. The task would have appalled any common man; but the natural talents of Mr. Morris, together with his experience and habits of despatch, derived from his extensive commercial concerns for a long series of years, and an uncommon readiness, great assiduity and method in business, with decision of character, enabled him to surmount all the difficulties that lay in his way. An inspection of the official statement of his accounts, will at once show the serious nature of the multifarious duties attached to the office, and the pressure of his engagements; but an opportunity of so doing, even if wished for, can be had by few. Some idea may be formed of them, when it is known, that he was required "to examine into the state of the public debts, expenditures, and revenue; to digest and report plans for improving and regulating the finances; and for establishing order and economy in the expenditure of public money." To him was likewise committed the disposition, management, and disbursement of all the loans received from the government of France, and various private persons in that country and Holland; the sums of money received from the different states; and of the public funds for every possible source of expense for the support of government, civil, military, and naval; the procuring supplies of every description for the army and navy; the entire management and direction of the public ships of war; the payment of all foreign debts; and the correspondence with our ministers at European courts, on subjects of finance. In short, the whole burthen of the money operations of government was laid upon him. No man ever had more numerous concerns committed to his charge, and few to a greater amount; and never did any one more faithfully discharge the various complicated trusts with greater despatch, economy, or credit, than the subject of this sketch. The details of his management of the office of finance, may be seen in the volume which he published in the year 1785.* It is well worth inspecting by every American. The preface,† in particular, should be read attentively, as he will from it form some idea of the state of public affairs, as to money, at the time; of the difficulties attending the revolutionary struggle on that account, and the means by which our independence was secured, or greatly promoted, and for the enjoyment of which he ought never to cease to be thankful.

The establishment of the Bank of North America forms a prominent item in the administration of Mr. Morris. The knowledge which he had acquired of the principles of banking, and of the advantages resulting to a commercial community from a well regulated bank of discount and deposit, in enabling merchants to anticipate their funds in cases of exigency, or of occasions offering well grounded schemes of speculation,‡ rendered a hint on the subject of the importance of a bank to the government, enough; and he accordingly adopted it with warmth. Such an institution had been previously suggested, and as already said, an attempt at one, although with paper-money, but backed by the bonds of responsible men, had been made the preceding year. The greater facilities which one with a specie capital promised, in enabling the government to anticipate its revenue, and to increase the quantity of circulating medium, and promote trade, were forcibly impressed on his mind, and induced him to propose it to Congress. In May, 1781, he presented his plan, which was approved of by that body. Subscriptions were opened shortly after; but, in the following November, when the directors were elected, "not two hundred out of a thousand had been subscribed, and it was some time after the business of the bank was fairly commenced," before the sum received upon all the subscriptions amounted to $70,000." Mr. Morris, no doubt, became sensible that such a capital would go but a little way in aiding him in his financial operations for government, and at the same time accommodate the trading part of the community. He therefore subscribed $250,000 of the $300,000, (which remained of the money received from France,) to the stock of the bank, on the public account: $450,000 had been brought from France, and lodged in the bank, and he "had determined, from the moment of its arrival, to subscribe, on behalf of the United States, for those shares that remained vacant; but such was the amount of the public expenditures, that notwithstanding the utmost care and caution to keep this money, nearly one half of the sum was exhausted before the institution could be organized."§ It was principally on this fund that the operations of the institution were commenced; and before the last day of March, the public obtained a loan of $300,000, being the total amount of their then capital. This loan was shortly after increased to $400,000.‖ Considerable facilities were also obtained by discounting the notes of individuals, and thereby anticipating the receipts of public money; besides which, the persons who had contracted for furnishing rations to the army, were also aided by discounts upon the public credit. And in addition to all this, the credit and confidence which were revived by means of this institution, formed the basis of the system through which the anti-

* A statement of the accounts of the United States of America during the administration of the superintendant of finance, commencing February, 1781, ending November, 1784.

† It commences thus:

"*To the Inhabitants of the United States.*

"FELLOW-CITIZENS,

"That every servant should render an account of his stewardship, is the evident dictate of common sense. Where the trust is important, the necessity is increased; and where it is confidential, the duty is enhanced. The master should know what the servant has done. To the citizens of tbe United States, therefore, the following pages are most humbly submitted."

‡ Mr. Morris stated, in his speech on tbe renewal of the charter of the Bank of North America, that before the American war, he had "laid the foundation of a bsnk, and established a credit in Europe for the purpose. From the execution of the design, he was prevented only by the revolution." Debates, p. 37.

§ Debates on Bank, p. 48.

‖ The sum total brought into the public treasury, from the several states, not amounting to $30,000 upon tbe last day of June.

cipations made within the bounds of the United States had, in July, 1783, exceeded $820,000. If the sums due, (indirectly) for notes of individuals discounted, be taken into consideration, the total will exceed one million! It may then not only be asserted, but demonstrated, that without the establishment of the national bank, the business of the department of finance could not have been performed."

Besides this great benefit to the public cause, derived from the bank; the state of Pennsylvania, and city of Philadelphia, by loans obtained from it, were greatly accommodated. It enabled the first to provide for the protection of the frontiers, then sorely assailed, and to relieve the officers of the Pennsylvania line from their distress, occasioned by the failure of the internal revenue, which had been mortgaged for payment of interest of certificates granted them for military services. It enabled the merchants to clear the bay, and even river Delaware, of the hostile cruisers (which destroyed the little commerce that was left, and harassed our internal trade,) by fitting out, among other armed vessels, the ship "Hyder Ally," which, under the command of the late gallant Barney, in four days after she sailed, brought into port the sloop of war General Monk, which the British, with accurate knowledge of all public movements, had fitted out at New York, with the particular object of capturing her.* By its loans, the city authorities relieved the pressing wants of the capital, which suffered in a variety of ways from the exhausted state of its funds, the necessary consequence of the war. But the support of public credit, the defence of the state and harbour, and relief of the city funds, were not the only results from this happy financial expedient of Mr. Morris: for by its accommodations to the citizens, it promoted internal improvements, gave a spring to trade, and greatly increased the circulating medium by the circulation of its notes, which, being convertible at will into gold or silver, were universally received equal thereto, and commanded the most unbounded confidence. Hundreds availed themselves of the security afforded by the vaults of the bank to deposit their cash, which, from the impossibility of investing it, had long been hid from the light; and the constant current of deposits in the course of trade, authorized the directors to increase their business, and the amount of their issues, to a most unprecedented extent. The consequence of this was a speedy and most perceptible change in the state of affairs, both public and private.

In the same year, an additional mark of confidence reposed in the talents and integrity of Mr. Morris, was evinced by the legislature of Pennsylvania, by their appointment of him as their agent to purchase the supplies demanded of the state for the public service. By the nature of the organization of the general government, the annual necessities of the public funds, provisions and other supplies were apportioned among the several states, and large demands were made upon Pennsylvania in 1781. Mr. Morris was appointed to furnish them, and a particular resolve of Congress permitted him to undertake the trust. The supplies were furnished in anticipation, before the money was obtained from the state treasury, and while he thus enabled the state promptly to comply with the demands of Congress, he shows, by his account of the transaction, that the plan of his operations was more economical than any other, which, under the state of things at the time, could have been adopted. Those only who are old enough to recollect the state of parties at the time in Pennsylvania, or have made themselves acquainted with them, can duly appreciate the extent of the compliment paid to Mr. Morris by his appointment upon the occasion mentioned. Political feuds, arising in part from a difference of opinion on the subject of the constitution of Pennsylvania of 1776, prevailed to a great extent, and the conduct of the ruling party, who were opposed to any change in that feeble instrument, was, on many occasions, marked by want of both intelligence and liberality of sentiment. Mr. Morris was considered the head of what they chose to term the aristocratic party, that is, that portion of men of wealth, great public consideration, superior education, and liberal ideas, who ardently wished a more energetic form of state government than could exist under a single legislature, and numerous executive council; and could the legislature have dispensed with his services, or had there been any man among the party in power, capable of fulfilling the trust, it is probable that he would not have been appointed to it. That man, however, did not exist. The manner in which Mr. Morris executed it, showed how well he merited the confidence of the legislature, and also a skilfulness of management, which none but himself could have effected.†

In the year 1786, Mr. Morris served as a representative of Philadelphia, in the state legislature. Always ready to lend the aid, either of his talents, time, or purse, when required by the cause of his country, or state; he consented to the wishes of his fellow-citizens in standing as a candidate, for the express purpose of exerting his influence in favour of the renewal of the charter of the Bank of North America, which had been taken away from that institution by the preceding assembly. The ostensible reasons for this unjust measure were ill-grounded fears of the evil effects of the bank on society, (and especially the agricultural interest,) its incompatibility with the safety and welfare of the state; an improbable possibility of undue influence from it on the legislature itself; with other arguments of equal weight and truth. But the real cause must be ascribed to the con-

* The following statement of the comparative force of the two vessels, and merit of the capture of the Monk, was published in a newspaper of the day.

1. The General Monk carried 18 nine pounders; the Hyder Ally carried only 4 nines and 12 six pounders.
2. The General Monk carried 130 men: the Hyder Ally only 120 men.
3. The General Monk was completely fitted for sea, and was officered and manned with a crew regularly trained, and perfectly disciplined, by long experience, in the British navy. The Hyder Ally was a letter of marque a few days before the battle. Most of her officers were young men. Her captain brought up in a counting-house, and became a sea-officer, as many of our farmers, lawyers, and doctors became generals, from necessity and patriotism. The crew was picked up the week before in the streets of Philadelphia; many of them were landsmen, and most of them had never been in action before.
4. The General Monk lost 53 men in killed and wounded; the Hyder Ally lost only 11.

Add to these circumstances, that the victory, under all these disparities, was obtained in 25 minutes, and it will appear to be one of the most honourable exploits to the flag of the United States, that occurred during the war.

† See the Statement of his Finance Accounts, before referred to.

tinuance of the spirit of the same party which had been so violently opposed to Mr. Morris, and the society with which he associated during the whole of the American war. The debates on the occasion, which excited great interest among all classes of society, were accurately taken down, and published in a pamphlet.* Mr. Morris replied to all the arguments of his opponents with a force of reasoning that would have produced conviction in the minds of any men, not previously determined to destroy the bank, if possible, at all hazards. The question, however, was lost by a majority of 13, (28 to 41.) The succeeding legislature restored the charter.

The next public service rendered by Mr. Morris to his country, was as a member of the convention that formed the federal constitution in 1787. He had, as a part of his colleagues, Benjamin Franklin, George Clymer, and James Wilson, with whom he assisted in the councils that led to the memorable and decisive measures of the year 1776; and now with them again united in forming the bond of union, which was to lay the foundation for the future and permanent prosperity of their country. The want of an efficient federal government in conducting the war, had been severely felt by all those at the head of affairs, either in a civil or military capacity, and most particularly by Mr. Morris, while a member of Congress, and afterwards when the financial concerns of the Union were exclusively committed to him; and the necessity of it, "one, which would draw forth and direct the combined efforts of United America," was strongly urged by him, in the conclusion of his masterly preface to the "Statement of his Finance Accounts," already referred to.

The confidence of his fellow-citizens was again shown, in his election as one of the representatives from Philadelphia, in the first Congress that sat at New-York after the ratification of the federal compact by the number of states required thereby, to establish it as the grand basis of the law of the land.

It adds not a little to the merit of Mr. Morris to be able to say, that notwithstanding his numerous engagements as a public or private character, their magnitude, and often perplexing nature, he was enabled to fulfil all the private duties which his high standing in society necessarily imposed upon him. His house was the seat of elegant, but unostentatious hospitality, and his domestic affairs were managed with the same admirable order which had so long, so proverbially distinguished his counting-house, and the offices of the secret committee of Congress, and that of Finance. This happy union of well-conducted official and domestic concerns, was owing, in the first case, to his own superior talents for despatch, and method in business, and, in the last, to the qualifications of his excellent partner, the sister of the esteemed bishop of Pennsylvania, Dr. White. An introduction to Mr. Morris, was a matter of course, with all the strangers in good society, who for half a century visited Philadelphia, either on commercial, public, or private business, and it is not saying too much to assert, that during a certain period, it greatly depended upon him to do the honours of the city: and certainly no one was more qualified or more willing to support them. Although active in the acquisition of wealth as a merchant, no one more freely parted with his gains, for public or private purposes of a meritorious nature, whether these were to support the credit of the government, to promote objects of humanity, local improvement, the welfare of meritorious individuals in society, or a faithful commercial servant. The instances in which he shone on all these occasions were numerous. Some in reference to the three former particulars have been mentioned, and more of his disinterested generosity in respect to the last could be given, were the present communication intended to be any thing more than a hasty sketch. The prime of his life was engaged in discharging the most important civil trusts to his country, that could possibly fall to the lot of any man; and millions passed through his hands as a public officer, without the smallest breath of insinuation against his correctness, or of negligence, amidst the "defaulters of unaccounted thousands," or the losses sustained by the reprehensible carelessness of national agents.

From the foregoing short statement, we may have some idea of the nature and magnitude of the services rendered by Mr. Morris to the United States. It may be truly said, that few men acted a more conspicuous or useful part; and when we recollect that it was by his exertions and talents that the United States were so often relieved from their difficulties at times of great depression and pecuniary distress, an estimate may be formed of the weight of obligations due to him from the people of the present day. Justly, therefore, may an elegant historian of the American War say, "Certainly the Americans owed, *and still owe*, as much acknowledgment to the financial operations of Robert Morris, as to the negotiations of Benjamin Franklin, or even the arms of George Washington.†"

After the close of the American war, Mr. Morris was among the first in the States who extensively engaged in the East India and China trade. He died in Philadelphia, in the year 1806, in the 73d year of his age.

MEASE.

MORTALITY, BILLS OF. See ANNUITIES.

MORTAR. See ORDNANCE.

MOSAIC, commonly designed *Painting in Mosaic*, is a mode of representing objects by the union of portions of stone or glass, reduced to an even surface. But it is always a copy, for artists in Mosaic never compose.

The materials are few and simple, consisting merely of the substance with which the picture is to be represented, formed into cubes, parallelopipeds, or other polygonal figures, as required, and retained by one end in a strong cement, to preserve the union of the whole. Their colour, size, and substance, are arbitrary with the artist, according to the subjects and future position: all, however, are of the most durable kind. The ancient Mosaics consisted chiefly of marble and coloured glass or pastes; the modern are composed of marble, glass, enamel, and sometimes of the harder stones, as agate, cornelian, lapis lazuli, and even jewels. From the variety of design, and diversity of shades, the works of the latter evince great superiority over the former, for the ancients used few colours, and the same design was frequently repeated.

In general, Mosaics are composed of cubes, or short parallelopipeds, that is, oblong pieces of from two inches of a side, down to fragments of the smallest surface, as is seen in a portrait of Pope Paul V. where the face alone consists of 1,700,000 portions, each no larger than

* For this interesting document, we are indebted to Mr. Mathew Carey, as writer and publisher.

† Botta's Hist. Am. War, vol. iii. p. 343.

a grain of a millet. The Mosaic of the cupola of St. Peter's at Rome, on the other hand, is formed of unpolished coloured stones, of from half an inch to two inches square; and pavements appear in pieces still larger. Of this last description, or of what may be called large Mosaic, the pieces are reduced to the necessary size by sawing and grinding, after the ordinary operations of the lapidary; those of glass, which is in universal use, are broke down from rods, drawn out of a suitable shape; but glass being a refractory substance, enamel is substituted for it, as it is more easily managed in reduction. The enamel which is used for smaller pictures, is drawn out into long quadrangular rods while fused, and these are broke across with a hammer, or divided by a file into portions longer or shorter as required. It is so fusible, that the rods of inconsiderable size, may be drawn out by the flame of a candle, without assistance of the blow-pipe. In using the finer hard stones, they also are fashioned into the proper form, by the art of the lapidary; but the expense of purchase, and the labour of workmanship, restrict the fabrication of such Mosaics. Most of the enamel employed for this purpose was formerly prepared in Holland and at Venice, in small round cakes, four or five inches in diameter, and five, six, or eight lines thick, which were sent to the chief places of manufacture in Italy, as Milan, Rome, and Florence. Being dexterously struck with a hammer, on an anvil of a particular shape, fragments more regular than those of other substances fly off in the fracture, and commonly approaching an oblong form. At Rome, where it is now carried on extensively, all the materials are compounded.

Such artificial substances are prepared of a vast variety of different shades, in order to obtain the suitable gradation of colour in the picture. Hence the present number of tints in Mosaic is said to amount to no less than 15,000 or 17,000, proceeding by a nicety almost inconceivable. About 50 years ago they were computed at 4000: and it seems evident that the increase has been great and gradual, and most probably an object of more attention in later times; for ancient Mosaics, on which considerable labour has been bestowed, appear in only three colours.

The numerous fragments from each species of substance are all arranged in drawers, boxes, and cases regularly labelled, from which they are withdrawn by the artist for his work, as the compositor selects types for printing. It is necessary to explain, that, in composing a large picture in Mosaic, the foundation or back of the picture consists of a stone called piperno. Several oblong pieces, together equal to the whole surface, are taken, each some inches thick, whereby wonderful strength and solidity are acquired, and hollowed to the depth of about three inches and a half, leaving a border all around, with which the work, when completed, will be level. The excavated surface is intersected by transverse grooves, about an inch and a half deep, and somewhat wider at the bottom than the top, in order to retain a quantity of cement or mastic which fills them, the line of the grooves joining in an inclined direction from each side, so as to form an angle in the middle. The separate pieces are then nicely adjusted together, by strong iron cramps behind. Or let it be supposed that a large marble slab is hollowed to the depth of three inches and a half, leaving a projecting and prominent border, the fragments are imbedded in it, to form the picture. This bed or frame is gradually filled with a strong and durable kind of cement or mastic, on the composition of which we shall not here enlarge, both from the general attention now paid to substances of that nature, and because different artists compound them after a different fashion. As the frame is filled, the picture is delineated on the cement, the same way as painting in fresco; and the fragments of enamel being selected for a small portion of it at a time, they are successively beat into the cement with a small flat wooden mallet, until the top of the whole is level, or nearly so. When the artist observes that the fragments so arranged are not suitable to his taste and expectations, he removes them, or substitutes others, which is easily done before the cement hardens, but subsequently it is a more difficult operation. Proper cement remains in a state to receive fragments during fifteen or twenty days, by observing the necessary precautions.

The foundation or back of pictures of smaller size, consists of hammered iron or copper, instead of stone, the surface of which is interspersed with small tin cramps or brackets, like reversed staples, for the purpose of retaining the cement. They are merely slips of metal, bent up at each end, and soldered by the middle to the plate, thus producing inequalities, which operate in the same manner as the grooves of the former Mosaics. The foundation of pavements is of the most solid description, consisting of strong beds of masonry, rising towards the surface of the ground, and are fitted to receive the cement and materials of the representation.

After the whole picture is composed, its surface is ground down to a perfect plane, in a manner similar to what is practised in grinding mirrors, and a polish is given to it with putty and oil. During the progress of these operations, any crevices betrayed at the joints are filled with pounded marble or enamel, mixed with wax, which penetrates by passing a hot iron over them. The kind of polish, however, is regulated by the position and use proposed for the Mosaic, and of late it is not so high as formerly.

Although we have said that cubes or parallelopipeds are employed, the figures are not invariably angular, because curves are sometimes required; and from the ductility of glass, the portions forming a rose, for example, are curvilinear.

Large compositions in Mosaic are tedious, requiring several years to execute; and the grinding and polishing of the surface of a picture are extremely laborious. But it is not necessary that the whole parts should be the work of one individual, as equal skill throughout is scarcely ever indispensable, both because large portions are of a uniform description, and because some may be less artificially arranged. The qualities of Mosaic are various, often being rudely designed, and coarsely executed. Sometimes so little attention is paid to the intimate union of the cubes, that the cement rises between them to form part of the surface, and in general it cannot bear narrow inspection. The most skilful artists, however, have produced works so delicate as to be compared to the finest painting.

From this general description, the substance and structure of Mosaic will be easily understood. It may be carried to an unlimited extent; and in fact spacious pavements, the incrustation of walls, the ornamenting of cupolas, and lining of arches, appear in it in various countries. Italy, always the seat of the arts, engrosses almost the whole Mosaic manufacture of Europe. In

Rome there is a large establishment belonging to the Pope, where this kind of painting is conducted on a great scale. The different materials are arranged in numerous apartments, from which they are removed by the artists as having occasion for them. Besides this establishment, there are many artists in Rome occupied in smaller works, such as pictures, full length figures, whose dimensions do not exceed two or three inches; birds, insects, and baskets of flowers, all in miniature, of exquisite execution. The Mosaics for personal ornaments and toys are innumerable, and they are now common in Britain. The most celebrated modern Mosaic picture has been just completed at Milan, after Leonardi de Vinci's painting of the last supper, preserved in a suppressed convent of that city. This great work is about 24 feet in length, by 12 in breadth, imbedded on 12 slabs of marble obtained from the Lago Maggiore. It is the production of Rafaelli, an artist of the Roman school, by whom eight or ten men were employed on it daily during eight years; and it cost 7500*l.* Sterling. Originally commissioned by Bonaparte, his expulsion is said to have thrown it into the hands of the artist, from whom it was purchased by the present emperor of Austria.

Mosaic appears to greatest advantage at some distance; nor can it be compared in general to the delicacy, smoothness, and uniformity of painting. But its superiority is affirmed to consist in greater durability, and resisting the influence of damp, and the attack of insects; its not suffering from exposure to the sun; in preserving the permanence of colour, and requiring no particular light for embellishment. Yet all these properties are so far counterbalanced by the weight of the materials, tediousness and expense of execution, together with other obstacles, as will prevent Mosaic from competing, in most countries, with painting.

Analogous to Mosaic is the *pietra dura*, or Florentine work, which consists of the union of irregular portions of hard stones containing the gradation of colours in each, instead of obtaining that gradation by the union of multiplied fragments. Some fine specimens of this are preserved at Florence, such as a slumbering Cupid reposing on a lion.

The art of working in Mosaic ascends to high antiquity, and probably preceded painting. It is not obvious, however, as some have asserted, that it was known to the Jews, although that nation was acquainted with singular pavements; for the Koran relates, that when the Queen of Sheba visited Solomon, she was received in a hall where she mistook the pavement for water, and bared her limbs; on which Solomon said, "the floor is solid: it is made of glass." Likewise, amidst the wonders beheld by John, in the Revelation, was "a sea of glass like unto crystal." But other eastern nations were acquainted with Mosaic; for in the palace of Ahasuerus was "a pavement of red, and blue, and black marble," *Esther*, chap. i. v. 6. Ciampini, an author who has bestowed much investigation on this subject, ascribes the invention of Mosaic to Persia, of which there does not seem to be satisfactory evidence; and it must be admitted that there is considerable uncertainty as to the precise country over which Ahasuerus reigned.

The name *Mosaicum*, *Musiacum*, or *Musivum*, was first employed only towards the fourteenth century; and the words *pavimenta Lithostrata*, *sectilia*, *secta*, or *tesselata*, were used to denote mosaics properly so understood by the ancients. Thus it is affirmed that the painted floors of the Greeks gave way to mosaic; and Pliny observes, that *Lithostrata acceptavere jam sub Sylla parvulis certe crustis extat hodieque, quod in Fortunæ delubro Praeneste fecit. Pulsa deinde ex humo pavimenta in cameras transiere e vitro*, lib. xxxvi. cap. 60, 64. Athenæus speaks of the rich pavements in the palace of Demetrius Phalereus, lib. xiii. § 60; and Hiero, king of Syracuse, is said, by the same author to have had an extraordinary ship constructed, in which the tesselated pavements of the cabins represented the whole fable of the Iliad, lib. v. § 41. Thus the art was familiar to other nations as well as to the Romans, from whom our acquaintance with it is derived. Isidorus afterwards designs real mosaic very distinctly, by *lithostrata parvulis crustis ac tessellis junctos in varios colores*—*De Origin.* lib. xv. cap. 8. *Pavimentum sectile* was composed of large compartments of marble; *sectum* merely of alternate square pieces; *tesselatum*, or *quadratorium*, from the word *tessera*, a die constituted real mosaic, of small cubes of glass or marble; and the *pavimentum vermiculatum*, consisting of the same, received that name only from its peculiar figure. Learned foreigners remark, that it is only in Britain that the correct designation of mosaic is preserved in *tesselated pavement.* The art of colouring glass practised in the age of Augustus, greatly promoted the use of mosaic; it became so common, that at length, Seneca, reproaching the luxury of his cotemporaries, complains, that they seemed unwilling to tread, unless upon precious stones. *Eo deliciarum pervenimus ut nisi gemmas calcare nolimus*, Ep. 86.

From the Romans it spread into their provinces, and as they had the sovereignty of Europe, there are few countries where relics of Mosaic are not now discovered. Justinian also decorated the church of St. Sophia, in Constantinople, during the sixth century, with works of the same kind, which are partly doublets or pieces of glass united horizontally, with a coloured foil interposed, as may be seen at this day. Some of the earliest popes decorated the churches of Italy with Mosaic, but the art declining there from the fifth or sixth century, is believed to have been almost totally lost, until Andrea Taffi learned it from a Greek artist Apollonius, who was employed on the church of St. Mark, at Venice, in the thirteenth century. This is to be viewed as the source of the modern Mosaic, which, as we have observed, has attained an infinitely greater perfection in some respects than that of the ancients, and has been carried to a great extent. The names of few of the ancient artists have come down to us, but among others those of Dioscorides, a Samian, and Archimedes, a Syracusan, are preserved. Many of the moderns are celebrated, from Giotto in the fourteenth century down to Tucca in the sixteenth; Mancini, Calandra, Lafranc, in the seventeenth; Cristofori, Brughi, Calendrelli, Camucci, and many more in the eighteenth and nineteeth.

The price of Mosaic depends on the quality and extent of the work, in which there is as great a difference as in any paintings. Pictures of large size have cost £5000, £6000, or more. Small personal ornaments or toys can be obtained for a few shillings. There are masters in Mosaic as well as in painting.

The greater Mosaic works of the ancients probably were devoted to their halls and baths, while that of the moderns is employed in churches. None of the former are found entire, or with the rarest exceptions, but portions are frequently disclosed in the course of excavation, which enable us to judge sufficiently of the extent, design and execution of them. Some persons erroneously suppose that the colour of stones and marble is permanent, but it fades in both, almost without exception, on long continued exposure in the air.

One of the finest ancient Mosaic pavements extant, was discovered at a village near Seville in Spain, in the year 1799, at the depth of three feet and a half from the surface, from a brief description of which the nature of others may be comprehended. It extends above 40 feet in length, by nearly 30 in breadth, and contains a representation of the circus games in a parallelogram in the centre, three sides of which are surrounded by circular compartments, containing portraits of the Muses, interspersed with the figures of animals, and some imaginary subjects. In the race course are seen a chariot overturned, the charioteer thrown out of his seat, horsemen dismounted, fractious steeds, and broken harness. The charioteer, having been injured by his fall, is supported by two men belonging to a different faction or party, as may be ascertained by their costume, which, in all the figures, is well represented; the horses are of a deep brown colour; they have a cut tail like our modern fashion, and are apparently full of spirit. Various persons interested in the games appear in other portions of the course, and beyond it; but part of the whole pavement has been destroyed, by the waste of time and the injury of the workmen by whom it was discovered. A double row of circular compartments bound the sides of the course, some of which are very entire. Each is about three feet and a half in diameter, ornamented by a broad circular border as a frame. The whole plan is finished by an exterior border, highly embellished. Nine of these compartments are occupied by busts of the nine muses, arranged after the manner prescribed by Hesiod, and in the order of the books of Herodotus, but alternately, so that a compartment containing a mask, or an animal, or some other subject, is always interposed between two. The name of each muse is inscribed in her respective compartment, and several have their respective attributes, concerning which antiquaries have been frequently at variance, nor is it probable that the ancients themselves absolutely coincided on the subject. Calliope has a book, Polhymnia a lyre, those of Erato and Terpsichore are not equally obvious. The countenance of the muses is handsome, deep brown, as if belonging to a southern climate, with regular features, and fine large animated eyes. All have darker or lighter auburn hair, artificially disposed after different fashions, and some have ornaments on the head. They have for the most part a cloth thrown over an under garment, the latter appearing in Urania to be a robe.

The other compartments are occupied by a centaur, the genius of the circus games; children in different-coloured tunics, representing the seasons; and animals either finished or outlined. The floor also between the different compartments exhibits various birds, fruits, and flowers. Great diversity of colour is seen in this mosaic, without that delicate and regular degradation, however, which is employed by the moderns; but we are compelled to refer the reader to the splendid work of M. Laborde on the *Mosaics of Italica*, for further illustrations of this composition. The pavement is supposed to have belonged to the hall of the baths of a palace or city of that name, which was founded 208 years before Christ, and that it was constructed anterior to the reign of Domitian.

In the year 1806, a fine mosaic pavement, of lesser dimensions, but relative to the same subject, was discovered at Lyons, which M. Artaud ascribes to the first century of the Christian era. It is composed of small marble cubes, sometimes interspersed with pastes of different colours; and extends fifteen feet and a half in length, by nine and a half in breadth, exclusive of an ornamental border. The whole details of the games of the circus are represented here, from which it appears that no less than eight chariots started at a time, some of which are broken, and the horses and charioteers have fallen, as in the mosaic of Italica; for it was a point of address among the ancients to overthrow their competitors in the course. Some of their horses are white, grey, or pale bay; their figures are elegant and animated, and they exhibit "a cut, set tail, after the English fashion." A number of persons, in their peculiar costume, seem to have a share in the games; and in general those presiding are clothed in blue, which M. Artaud conjectures to have been the national colour of the Gauls. From this and the preceding mosaic of Italica, several passages of the classical authors are illustrated, which have hitherto embarrassed antiquaries. Artaud, *Description d'un Mosaique*.

The ordinary subjects seem to have been the Circensian games, theatrical scenes, marine deities, tritons, and nereids, all as requiring a large space, and adapted to the situation. Nothing has been more celebrated, on another scale, than three pigeons washing themselves, and a fourth drinking from the vessel, composed of marble fragments, not exceeding a line square, and adjusted with admirable precision. Many of the ancient mosaic works, we have seen, were devoted to the embellishment of halls and baths, and exhibited lively representations; but with the decay of the Roman empire, they were employed in the decoration of churches, and their subjects altered to those of a grave character. On the roof of the baptistery of the church of St. John at Ravenna, the baptism of Jesus Christ is represented in mosaic, ascribed to the fifth century. The ceremony is performed partly by sprinkling, and partly by immersion. A circular compartment in the centre is occupied by Christ standing upright in the river, and John, holding a long misshapen cross in one hand, pours water from a shell, or some vessel, on his head with the other, while a dove descends above the former. It likewise contains a human figure inscribed *Jordann*, rising out of the water, which is probably a personification of the sacred river. This compartment is environed by full length figures of the twelve apostles, and the whole is surrounded by a border, consisting of pulpits, altars, and other subjects.

The church of St. Peter's at Rome, contains the most extensive collection of modern mosaics extant, whether in decorating the cupolas, tombs, or altars. There are many pictures of large size, after the paintings of Raphael, Guido, Carlo Maratti, Guercino, and other great masters, representing either portions of scriptural history, the miracles of later saints, or events of their lives. It is here that, the works of distinguished artists being accumulated, we are enabled to judge of their respective talents. Independent of these, many ancient mosaics are to be seen in other churches, and in the various museums of that city.

With respect to the mosaics which have been discovered at different times in Britain, which was so long a Roman province, sufficient information will be found in the *Archæologia*, and *Monumenta Vetusta*, another work published by the London Society of Antiquaries, and the works of Mr. Lysons; and for an account of mosaics in general, the treatises of *Ciampini* and *Furietti* may be consulted. See also Cadell's *Travels in Carniola and Italy*, vol. i. p. 517, vol. ii. p. 202, and the *Edinburgh Philosophical Journal*, vol. ii. p. 348, and vol. iii. p. 419. A very splendid work on mosaics is now publishing by M. Artaud of Lyons. (*c.*)

MOSAMBIQUE, or MOZAMBICO, an island on the east coast of Africa, and the capital of the Portuguese settlements in that quarter. This island, which resembles a crescent, with the hollow part towards the sea, measures about two miles and a half in length, and a quarter of a mile in breadth. It is situated in 15° 10′ S. latitude, and 41° E. longitude, in the mouth of a bay nearly three miles in circuit, which furnishes a safe and convenient haven for shipping. On the north extremity of the island is a strong fort of an octagonal form, furnished with six bastions, and containing 80 pieces of cannon, besides a large howitzer, capable of casting stones of 100 lbs. weight. The situation is well chosen, and more than thirty of the guns bear upon the entrance into the harbour. In 1608, it resisted a vigorous attack of the Dutch, who landed in considerable force upon the island; and, after three weeks of unavailing exertion to reduce the place, were compelled to reimbark with loss. The anchorage is on the north-west side of the island, on a flat level sand, well protected from the sea, and within a musket-shot of the shore, where there is a very commodious landing-place, with steps on either side of a pier, which extends a considerable way into the sea. Immediately opposite to the anchorage lies the town of Mosambique, occupying the central part of the island, and presenting, in the appearance of its buildings and inhabitants, a strange mixture of Indian, Arabian, and European costume. The soil of the island is sandy, and tolerably fertile, yielding rice, millet, pulse, roots, &c.; but the settlement depends for its supplies on the peninsula of Cabaceiro, a tract of land about eleven miles long, and four broad, connected with the continent by an isthmus about a mile across, which could be easily rendered secure against any attack from the interior, were it not that the creek on the south side becomes dry at low water for the space of nearly four miles. On this peninsula are several villages and plantations, but none of them displaying much agricultural industry or skill. The principal trees are the cocoa-nut, cashew, mango, papaw, and orange; and the chief article of cultivation is the manioca root, which constitutes the food of the slaves. A great part of the land still remains uncultivated; but numerous herds of cattle, and vast droves of swine, are reared upon its pastures. A great variety of birds frequent the groves; and the most curious sea productions abound on the coast, such as star-fish, and sea-flowers of uncommon beauty, sponges of several kinds, sea-priapi, molluscæ, muscles, crabs, and oysters, which are said to yield pearls of considerable value. The beach is covered with flamingoes, spoonbills, curlews, snipes, and larks; large herons, and several species of gulls; and great numbers of slaves are generally seen at low water employed in collecting the shell-fish. One of the most remarkable of the fishes found on the coast, is the sucking-fish, or remora, which is said to be employed in catching turtles in the following manner: When fastened to the boat with a line, it invariably darts forwards, and fixes itself by its sucker to the first turtle which it meets, holding so strongly as to enable the fishermen to secure the prey.

The climate of Mosambique, from its oppressive heat and heavy atmosphere, is extremely unhealthy; and its fatal effects are so much increased by the mode of living, that both among the military and civilians, not more than seven out of a hundred are calculated to survive after a service of five years. With the exception of the governor and his staff, the greater part of the European settlers are culprits, who have been sentenced to banishment. The native planters, descended from the old settlers, have, in consequence of their dealing in slaves, become vicious, indolent, and careless of improving their plantations. Another class consists of the descendants of the old Arab settlers, most of whom are engaged in a seafaring life, and Banian traders and artizans. The remainder of the inhabitants is composed of the free blacks and native soldiers; and the whole population is calculated at little more than three thousand, of which the last mentioned class composes one half, and the two other classes about one fourth each. The European Portuguese and natives, are generally persons of little respectability and debauched morals; and the chief employment of both consists in the traffic of slaves, which renders them not very scrupulous about the means of gaining wealth. The regular salaries of all the public functionaries are so utterly inadequate for their support, that they are too much tempted to tolerate various abuses, such as selling the inferior offices of command, reducing the effective force of the settlement, and sharing in the perquisites which arise from the nefarious trade in slaves. This trade used formerly to supply the Cape of Good Hope, the Isle of France, and Batavia, with almost the whole of their slaves; besides sending a considerable number to the East and West Indies. Great part of this traffic is cut off by the abolition of the trade on the part of Great Britain; but still the settlement supplies the Brazil coast and Spanish colonies with above 4000 of these unfortunate creatures every year. They are bought at the rate of four or five pounds a head; and it is reckoned a lucky voyage, if, out of a cargo of 300 or 400, only 60 die in the passage to South America. To the Portuguese colonies in India, they send annually four or five vessels loaded with gold, ivory, and slaves, which bring back in return cottons, teas, and other kinds of eastern produce. All exports are exempted from duty, except slaves, which pay at the rate of 16½ crusades each. Imports, after all charges are included, pay about 25 per cent., except specie, which pays 2½, of which one per cent. goes to the revenue, and the rest to the governor. The most suitable articles for the market of Mosambique are iron bars, and hoops, lead powder, shot, cutlery, stationary, prints, and framed pictures, some articles of household furniture, cotton for sofas, silk and cotton stockings, shoes and boots, waistcoat pieces, light plain muslins, blue cloth, a few telescopes, salt butter, hams, and cheese, and a little of most articles of luxury in use among the Portuguese. Most of the goods for exportation bear a high price; but vessels may be supplied with provisions, consisting of bullocks, goats, and guinea-fowls, at a moderate rate. A considerable number of an Arabian breed of asses is also reared at Mosambique for exportation, which are generally sent to the Brazils as presents, but which fetch a high price when sold.

The articles exchanged with the Africans for their gold, ivory, and slaves, are chiefly salt, shells, beads, tobacco, coloured handkerchiefs, and coarse cloths from Surat.

It is a peculiar custom in the colony, that every person who can command a decent dress may visit the governor's house in the evening, which many take care to do, chiefly for the sake of obtaining a cup of tea; and whenever the governor removes to his country seat, it is esteemed a proper mark of respect to follow him, and make similar visits of ceremony. The wives of the planters (of whom few are seen in public) are generally thin and sallow in their complexion, negligent in the care of their persons, except on great occasions, and resembling those of the Cape in their taste for smoking tobacco, and the custom of going without stockings. The food of these planters is gross in the extreme, consisting of great masses of boiled meats, chiefly pork and beef, in the midst of vegetables; with quantities of oil, not remarkable for its purity, in most of their dishes.

The natives who occupy the country behind Mosambique, are the Makooa or Makooana, comprising a number of powerful tribes, extending northward as far as Melinda; southward, to the mouth of the Zambezi; and in a southwest direction, almost to the neighbourhood of the Caffres. They are an athletic and ugly race of people, of the most ferocious aspect, and savage disposition. They are fond of tattooing their skins, and draw a stripe down the forehead along the nose to the chin, which is crossed in a direct angle by another line from ear to ear, so as to give the face the appearance of being sewed together in four parts. They file their teeth to a point, so as to resemble a coarse saw; and suspend ornaments of copper or bone from a hole in the gristle of the nose. Their upper lip protrudes in a very remarkable degree; and this they consider as so principal a point of beauty, that they endeavour to make it still longer, by introducing into the centre a small circular piece of ivory, wood, or iron. They dress their hair in a very fantastic manner, some shaving one side of the head, others both sides, leaving a kind of crest from the front to the nape of the neck; while few of them wear simply a knot of hair on their foreheads. Their females resemble greatly the Hottentot women in the curvature of the spine, and protrusion of the hinder parts; and, when past the prime of life, are said to present the most disagreeable objects that can be conceived. They are fond of music and dancing; but their tunes and motions are unvaried and monotonous. Their favourite instrument is called Ambira, which is formed by a number of thin bars of iron of different lengths, highly tempered, and set in a row on a hollow case of wood, about four inches square, and closed on three sides. It is played upon with a piece of quill; and its notes, though simple, are sufficiently harmonious, sounding to the ear, when skilfully managed, like the changes upon bells. They are armed with spears, darts, and poisoned arrows; and possess also a considerable number of muskets, which they procure from the Arabs in the northern districts, and sometimes even from the Portuguese dealers. They are formidable enemies to the settlement; and have been rendered desperate in their hostilities, by the nefarious practices of the traders who have gone among them to purchase slaves. But, notwithstanding this natural ferocity, they are very docile and serviceable as slaves; and when partially admitted to freedom, by being enrolled as soldiers, they become both expert and faithful in the service. A few tribes on the coast, who speak the same language as the Makooa, and probably belonged originally to the same stock, had fallen under the jurisdiction of the Arab settlers; and, when these last were conquered by the Portuguese, became bound to pay tribute, and render military service. Their Sheiks are appointed by the governor of Mosambique; and some of them are so powerful as to be able to bring into the field from two to four thousand men; but as they seldom act in unison, little reliance can be placed on their assistance.

This coast had been known to the Arabs, and its ports frequented by their traders, for centuries before its discovery by Europeans; and all the information possessed by the latter on the subject, was chiefly drawn from the vague accounts of Ptolemy, and the Periplus of the Erythrean sea. It was first discovered by the Portuguese in the year 1497, who found the whole of the coast in the possession of the Arabs; but the fame of its gold mines, and the convenience of its ports, as resting places for the Indian trade, led them to attempt the expulsion of the original settlers. This was easily accomplished by their superiority in arms; and, in 1508, they had conquered Quiloa, gained a footing in Sofala, and built the fort which still stands on the island of Mosambique. They gradually encroached on the Mohammedan possessions in the river Zambezi; and, about the year 1569, they completely cleared that part of the river of the Arabs, by putting the whole of them to death. In the attempts of the Portuguese to reach the gold mines of the interior, they were not very scrupulous as to the means which they employed; and have furnished, in the history of the East, a parallel to the atrocities of their Spanish neighbours in the West. But theirs was a harder task; and the natives of Africa maintained a nobler struggle for the independence of their country, than the feebler South American race. Though compelled to abandon their fields and habitations to the rapacious invaders, they embraced every opportunity of harassing the enemy in their progress, or of taking them by surprise in their settlements. The most celebrated of these expeditions was undertaken at the command of Sebastian I. in 1570, and conducted by Francis Baretto, who had been purposely appointed governor-general of Mosambique. They penetrated the country of Monomotapa, and burnt its capital; but, after losing a great number of men, they were obliged to retreat with no other fruit of their victories, than permission to pass through the territories of Monomotapa, upon condition of paying an annual tribute of 200 pieces of cloth. Another attempt was soon after made through the country of the Mongas or Monjou; and, after a hard fought battle with the natives, the armament passed the forest of Lupata, and then, marching eastward along the line of the Zambezi, made every exertion to reach the silver mines of Chicova; but all their researches proved fruitless; and a detachment, which had been left behind to prosecute the object, was cut of by an ambuscade. Since this event, the Portuguese have contented themselves with acting on the defensive, occupying the coast along the line of the river Zambezi, and maintaining their influence in the country, by exciting the native powers against one another. Even in these limited views, they had many hard contests with the natives, and particularly in 1589 and 1592, they were attacked on the northern bank of the last mentioned river, by a wandering and ferocious tribe named Muzimbaj, who afterwards passed eastwards, and are conjectured to have belonged to the tribes of Galla, who penetrated to the frontiers of Abyssinia. The Portuguese were not more successful in attempts to convert the natives to the Catholic faith; and, though one of their most zealous missionaries, Gonzalvo de Sylva, gained access to the court of the Prince of Monomotapa, and made a favourable impression on his mind, the Mahomedan traders afterwards acquired the ascendancy, and effected the destruction of the Portuguese teachers. Most of their other converts, as has too ofen been the case in catholic missions, were merely nominal, and little benefited by the appellation of Christians. The value of this colony to Portugal has always been greatly overrated, but was probably greater in former times than it can be at present. It furnished large supplies of gold and ivory, and enriched at least a number of private individuals, whose wealth ultimately proved beneficial to the state. It afforded in the earlier voyages to the east an important resting place, and supplied most of the Portuguese colonies with slaves. Its trade and importance have naturally declined with that of the mother country, and especially with the loss of her eastern possessions; but the impolitic manner in which it has for a long time been governed, has farther reduced it to a state of weakness and insignificance which can scarcely withstand the attacks of the surrounding savages. During the war with France, and before the capture of the Mauritius by the British, it suffered greatly from the French privateers, and has recently been exposed to serious depredations from the tribe of pirates called Marati, who occupy the north-east point of Madagascar. See Purchas's *Pilgrim*; Salt's *Voyage to Abyssinia*; and *Histoire de l' Ethiopie Orient. par* C. R Jean des Santes. (*q.*)

MOSCOW, formerly the metropolis of the Russian empire, is situated in East Long. 37° 33′, and North Lat. 55° 45′ 45″. It was founded by George, son of Volodimir Monomaka, who ascended the Russian throne in 1154; but it was Daniel, the son of Alexander Neuski, who, by making it his residence as duke of Muscovy, laid the foundation of its future greatness, and, in 1304, made it the capital of the Russian dominions. In 1382, it was taken by Tamerlane, after a short siege, but soon came again into the possession of the Russians. It was frequently occupied by the Tartars, during the 14th and 15th centuries; but they were finally expelled by Joan Vassilievitch I. who rendered Moscow the principal city of the empire. It continued to be the metropolis of Russia till the beginning of the eighteenth century, when the seat of empire was transferred to Petersburgh; but it still continued to be the most populous city in the empire, and the residence of those nobles who did not belong to the court, and delighted to exhibit their ancient feudal grandeur. It stands in the midst of a fertile plain, watered by the river Moskwa, which flows round the greater part of the city. It is about twenty-six miles in circumference, and covers twelve times the area of Petersburgh. It does not contain, however, above 300,000 inhabitants, of whom about 50,000 are retainers and domestics of the nobles, who make their residence in the town only during the winter season. Its appearance, from a little distance, is very singular and splendid, presenting a numerous assemblage of spires glittering with gold, amidst burnished domes, and painted palaces.

There is no outer wall around the city, but only a simple parapet of earth. After entering this enclosure, the city seems to have disappeared, and nothing is seen but a wide scattered suburb, composed of "huts, gardens, pig-sties, brick-walls, churches, dung-hills, palaces, timber-yards, warehouses," &c. "One might imagine," says Dr. Clarke, "all the states of Europe and Asia had sent a building, by way of representative, to Moscow; and under this impression, the eye is presented with deputies from all countries, holding congress; timber-huts from regions beyond the Arctic; plastered palaces from Sweden and Denmark, not white-washed since their arrival; painted walls from the Tyrol; Mosques from Constantinople; Tartar temples from Bucharia; pagodas, pavilions, and virandas from China; cabarets from Spain; dungeons, prisons, and public offices from France; architectural ruins from Rome; terraces and trellises from Naples; and warehouses from Wapping." The general aspect of the buildings is a mixture of gothic and modern architecture: or rather that of a city built upon the Asiatic model, but gradually becoming more European. Many of the palaces, instead of a single structure, are formed of a vast assemblage of buildings, distributed into several streets, and bearing the appearance of a moderately-sized town. The streets are very long, and generally broad; but frequently narrow and dirty. Some of them are paved; but the greater part are merely floored with trunks of trees or plants, and covered with mud and dust. There is an endless variety in the style of the different buildings. Some of the wooden-houses are painted; many of the brick structures have wooden roofs, and others have iron roofs and doors. The churches, which are very numerous, have their domes of wood, or copper, or tin, gilded, or painted green. Nor are the different edifices assorted with any kind of uniformity; but wretched hovels are blended with spacious palaces; and cottages of one story stand next to the most superb and lofty mansions. "In a word," says Mr. Coxe, "some parts of this vast city have the look of a sequestered desert, other quarters of a populous town; some of a contemptible village, others of a great capital." "Or," as the Prince de Ligne has described it, "Moscow looks exactly as if three or four hundred great old chateaus had come to live together, each bringing along with it its own little attendant village of thatched cottages."

Moscow contains five distinct divisions or towns, each surrounded by its own wall, viz. the Kremlin, or fortress; the Kataigorod, or Tartar town; the Bielgorod, or White town; the Semlianogorod, or Circular town; and the Slabode, or Suburbs. The two first are situated on a central eminence, and are placed side by side; but around them lies the third town in a circle, which is in like manner surrounded by the fourth; and that again by the fifth, marking, by their several lines of circumvallation, the growth of the place in successive æras. 1. The Kremlin, which is of a triangular form, and about two miles in circumference, contains the citadel, with several churches and magnificent houses; and particularly the palace of the Czars, a building in the Hindoo style, above 200 years old, and one of the most gorgeous pieces of architecture in the city. This part of the town presents an assemblage of bright gay colours and gaudy ornaments; the cupolas and roofs being gilt, or stained with green and red; the walls and towers covered with glazed tiles of blue, white and yellow, or paintings of the Scripture history; a melange in short on every side of "peer-shaped domes, Tartar battlements, gothic tracery, Grecian columns, the star, the crescent, and the cross." 2. The Kataigorod, larger than the Kremlin, contains the University, the printing-house, several public buildings, the tradesmen's shops, and the only street in Moscow in which the houses stand close to each other. 3. The Bielgorod; and 4, the Semlianogorod, exhibit a strange mixture of churches, convents, palaces, brick and wooden houses, and even mean hovels like the cottages of the peasantry; and the 5, Slabode, is a vast irregular circle, surrounding all the other parts, and containing all kinds of buildings, besides corn fields, pasture grounds, and some small lakes, which give rise to the river Neglina. The churches in Moscow are very numerous; and, including chapels, are not less than 1000. Many of them, built of brick, are stuccoed or white-washed; but the greater part are constructed of wood, which is painted of a red colour. The most ancient of these edifices are generally of a square form, with a cupola and four small domes of copper or iron gilt, or of tin painted green. These cupolas and domes are usually ornamented with crosses, entwined with chains or wires. In the body of these churches, there are usually four square pillars supporting the cupola; and these, as well as the walls, are covered with paintings of enormous figures, and of rude execution. Over the door of each church is the portrait of the saint to whom it is dedicated, to whom the common people pay respect as they pass by, taking off their hats and crossing themselves, or sometimes by repeatedly touching the ground with their heads.

The bells which are amongst the most remarkable objects to be noticed in Moscow, are hung in belfries detached from the church; and are rung by a rope tied to the clapper. Some of these bells are of extraordinary size, and yield the most solemn tones. One of them in the belfry of St. Juan, is above 40 feet in circumference, and more than 57 tons in weight. "When it sounds," says Dr. Clarke, "a deep and hollow murmur vibrates all over Moscow, like the fullest and lowest tones of a vast organ, or the rolling of distant thunder." But the great bell of Moscow, the largest ever founded, is in a deep pit in the midst of the Kremlin, where it was originally cast. It never was suspended; and in consequence of water having been thrown in to extinguish a fire in the building erected over it, a large fracture was made in the bell. It has a white shining appearance, and is said to contain a very large proportion of gold and silver. The size of the base cannot be ascertained, as it is partly buried in the earth; but the circumference, within two feet of the lower extremity, is sixty-seven feet four inches; and the perpendicular height from the top twenty-one feet four inches and a half. In the stoutest part, about seven feet above the lip of the bell, where it should have received the blow of the hammer, it is above twenty-three inches thick; and the weight of the whole is computed to be 443,772 lbs. which at three shillings a pound amounts in value to 66,565*l.* 16*s.*

Another wonder of the Kremlin is the great gun, which admits of a man sitting upright in its mouth, and is about 18½ feet in length, and 10 inches thick at the lip. It is never used, and serves merely for ostentation; but it is surrounded with artillery of extraordinary length. One of the principal structures and public institutions of Moscow, is the Foundling Hospital, an immense quadrangular pile of building, capable of containing 8000 children, who are suitably instructed according to the occupation which they are desirous to follow, and who receive, at the age of 20 years, a sum of money, with various advantages for prosecuting their trade in any part of the empire. This institution, besides diminishing the practice of child-murder, (which is said to have been greatly prevalent before its establishment) diffuses the knowledge of the arts among the people, and increases the number of free subjects in the empire. All the shops of Moscow are collected together in one spot, in the division of Kataigorod, where the whole retail commerce of the city is carried on, and where there is the appearance of a perpetual fair. Every trade has its separate department; but the shops which sell fur and skins, occupy the greatest number of streets. There is a market held in a large open space, in one of the suburbs, where ready made houses of every variety are strewed upon the ground, and where a purchaser, upon specifying the number of rooms which he requires, may have a dwelling removed, raised, and occupied in the space of a week. The number of picture-dealers in Moscow is very great; and the houses of the nobles are filled with them; but they are almost all copies made with the most exact imitation, and in general are valued according to the splendour of the colouring, and fineness of finishing. The booksellers' shops, also, are seldom provided with books of real literary reputation, but are rather stored with toys than the instruments of science. The splendour of the equipages, and the number of horses attached to them, gives an appearance of wealth and grandeur far above the reality. There is hardly an individual above the rank of a plebeian, who has not four horses to his carriage; the greater part have six; but the postilions are generally ragged boys, and the coachman a peasant in his sheepskin, while the long traces of the horses are made of no better materials than ropes.

In the metropolis of an empire composed of so many different nations, rather united than assimilated, the manners, dresses, amusements, languages, and occupations of the inhabitants, present to the eye of a stranger the most wonderful variety. The amusements are of the most childish description; and the most respectable of the citizens, and even persons of rank, may be seen in public, whirling about in chairs, and screaming with pleasure. One of the most general luxuries, is that of the bath, which is taken in public, both by men and women, who may often be seen naked before these places of resort, talking together without any sense of shame. The citizens are fond of promenades, which, particularly during Easter, take place every morning and evening; and in which, besides the nobles in their carriages and on horseback, are seen the merchants' wives on donkies in their richest dresses, the peasantry shouting and singing, the gypsies dancing, piping, clapping of hands, and various kinds of revelry. Another favourite resort is the market on Sunday mornings, in a spacious area near the Kremlin, where people of every description assemble to purchase dogs, singing birds, peacocks, poultry, fire arms, curious pigeons, &c. Dogs and birds are the principal articles, and particularly the pigeons, in which the nobles of Moscow take great delight, and which are trained by the feeders to fly and return at command. The morals of this great city are extremely relaxed; and it is no uncommon thing for a number of hired prostitutes to be kept openly in the inns for the use of the guests.

Hitherto we have spoken of Moscow, as it existed previous to its occupation by the French army under Buonaparte in 1812; but, by the conflagrations to which it was devoted, both by the Russians and the French, at their respective evacuations of the city, it was almost entirely destroyed, except some of the more distant parts of the Slabode, where the houses were thinly scattered, and a few streets in the division of Bielgorod, which had been occupied by the French guards. Preparations were made, by Buonaparte's orders, to blow up the Kremlin; but, excepting one of the towers, and the church of St. Nicolas, the greater part of it was preserved by the exertions of the Russians. By official returns before the conflagrations, the wooden houses amounted to 6591, and those of stone or brick to 2567. When the French evacuated the town, there remained of the former only 2100, and of the latter 526. In the year 1814, there were refitted in wood 1480, and in stone or brick 1312. During the summer, when the weather permitted the people to bivouac in the streets amidst the ruined houses, about 170,000 inhabitants were collected; but the residence of this number could not be counted upon during the winter. Its appearance at that period is thus described by an intelligent English traveller. "It was from the road, as it passed under the turrets of the Petrousky palace, that we first beheld the myriads of domes and steeples that yet glittered among the ruins of Moscow; and a short hour brought us to the barriers. At our first entrance, few symptoms were seen of a nature to correspond with the gloomy appearance which we had been led to expect; but, as we advanced, the quarters of the Slabode or Fauxbourg, where wood had chiefly been used in building, exhibited destruction in its fullest extent, for the most part, a *champagne rasé;* now and then the shell of a house was seen standing in a blank space, and here and there a few bricks and stones yet remaining, pointed out the spot where a dwelling once had been. Moving onwards, we crossed the avenues of the boulevards; the trees were in full leaf and beauty, seeming to vary the view only to heighten its melancholy aspect. Leaving this, we passed to the central parts of the town, that were constructed with more durable materials, exhibiting occasionally a richness and elegance of exterior, that must have equalled, if not surpassed, the architectural magnificence of the most beautiful towns of Europe. But all was now in the same forlorn condition; street after street greeted the eye with perpetual ruin; disjointed columns, mutilated porticos, broken cupolas, walls of rugged stones, black, discoloured with the stains of fire, and open on every side to the sky, formed a hidious contrast with the glowing pictures which travellers had drawn of the grand and sumptuous palaces of Moscow. The cross lanes looked, even at this interval, as if unused to hear the sound of human tread: the grass sprung up amidst the mouldering fragments that scattered the pavements, while a low smoke, issuing perhaps from some obscure cellar corner, gave the only indications of human habitation, and seemed to make desolation "visible." See Coxe's *Travels in Russia;* Clarke's *Travels*, vol. i.; and James's *Travels*, vol. ii.

MOSES, the inspired lawgiver of the Jews, was the son of Amram and Jocabed: and was born in Egypt, A. M. 2433, and B. C. 1571. His name signifies "drawn out;" and was given to him by the daughter of Pharaoh, because she had drawn him out of the water. Being adopted by this princess, he was instructed in all the learning of the Egyptians, and spent the first forty years of his life at the court of her father. He is said by Josephus to have commanded the army of the Egyptians, in an expedition against the Ethiopians, whom he defeated and subdued. The next forty years of his life he passed in the land of Midian, where he took refuge from the vengeance of Pharaoh, and where he married the daughter of Jethro, the priest of that country. The last forty years of his life were employed in conducting the people of Israel to the land of Canaan, on the borders of which he died, in the 120th year of his age. The particulars of his history are so much connected with that of the Jewish people, and are so well known, by means of the sacred Scriptures, that they need not be detailed in this place. Little dependence can be placed upon the accounts given of him by Josephus, Philo, the Jewish Rabbins, and various profane authors; and it is only in his own writings, that any thing authentic can be found respecting his extraordinary character and miraculous services. The frequent notice, however, that is taken of him by many ancient writers, serves to confirm the truth of his own narrative, and to point him out as the most ancient author, of whom any authentic works remain. He is thus mentioned by Manetho, Cheremon, Apollonius, and Lysimachus, as quoted by Josephus against Appian, l. i. § 26 and 32.; by Eupolemus and Artapanus, as quoted by Eusebius. Prop. Ev. lix. c. 26—20.; by Strabo, Geog. lxvi.; by Trogus Pompeius, in Justin. hist. lxxxvi. c. ii.; by Pliny the elder, Nat. Hist. l. xxx. c. i.; by Tacitus, hist. l. v. c. iii.; by Juvenal, Sat. xiv. v. 96.; by Longinus on the Sublime, § 9.; by Numenius, as cited by Origin against Celsus, l. iv. p. 198.; by the author of the Orphic verses, a production of great antiquity; by Diodorus Siculus, l. i. who mentions Moses as one who ascribed his laws to the God Jaoh, which may be considered as a corruption of the name Jehovah, and also in his fortieth book, as preserved by Photius, Bib. No. 244, he speaks of him as a man of illustrious prudence and courage; by Poleman, Appion of Possidon, Ptolemy Mendesius, Hellanias, Philocorus, Castor, Thallus, and Alexander Polyhistor, as enumerated by Justin Martyr, Cohort. ad Gent. p. 9—11.

Some of the Psalms, particularly the xc. have been ascribed to Moses; and also the book of Job, or at least the rendering of it from the original Arabic into the Hebrew language. But these are no more than mere conjectures; and the only unquestionable writings of Moses, are the first five books of the Old Testament, generally called the Pentateuch, and which are supposed to have formed originally but one book.

The Editio Princeps of the Pentateuch, was published with the Hebrew Bible, printed at Soncini, 1488; and the first translation into English, by William Tindale, was printed at Marlborow, in the land of Hesse, by Hans Luft, 1530, and at Hamburgh in the same year. (*q*.)

MOTION. See Dynamics and Mechanics.

MOULINS, a town of France, and the capital of the department of the Allier, is situated in a fertile plain, on the right bank of the river which gives its name to the department. Moulins is divided into the old and new town, and has two suburbs. The streets are in general broad and well paved, but the houses look ill, from being built of differently coloured bricks. The principal public buildings are, the Military School, the Chateau, the Tower of Jacquemarre, the Churches of Notre Dame, the Carmelites, and the Jacobins, the Caserne, and the Bridge. The Military School is a splendid building on the north side of the town, is two stories high, has 28 windows in the length of its front, and a noble Ionic portal. The chateau, of which a part only remains, is now a prison. The tower of Jacquemarre, from which there is a fine view of the town, of the beautiful gardens of the Bercy, and the surrounding country, is merely a tower for a clock, on which the hours are struck by two men. The church of Notre Dame, which has never been finished, is handsome, with five buttresses, but has suffered much during the Revolution. Behind the altar is a fine representation of our Saviour's sepulchre. The church of the Convent of St. Marie, situated beside the military school, has a neat portal, but is remarkable chiefly for the tomb of the celebrated Duke de Montmorency, who was beheaded in the reign of Louis XIII. It is a splendid specimen of sculpture in marble, by Covsto. The remains of the duke and his duchess are deposited in a noble sarcophagus of black marble, with a simple inscription. Above the sarcophagus are recumbent statues of the duke and duchess. On the right hand is a statue of Generosity, and on the left a fine one of Hercules. Above these, on each side of the marble columns, are a statue of Mars with his spear, and of Religion with her cross. The Chateau d'Eau, which supplies the town with water, is an elegant little building. The collegium, which seems to have been a huge building, is in ruins. The town is almost surrounded with a splendid promenade, flanked with fine poplars. Moulins contains also a public library, public baths, and a small theatre. The principal article manufactured here is scissors. The town has very little trade. Population about 14,000. East Long. 3° 20′ 5″, and North Lat. 46° 34′ 4″.

MOUNTAINS. See Mineralogy, in this volume, and Physical Geography.

MOURZOUK, the capital of the kingdom of Fezzan, is situated in 27½° of south latitude, and 15½ of east longitude. It is the great market and place of resort for various caravans from Cairo, Bengasi, Tripoli, Gadames, Twat, and Soudan, and for the smaller troops of African traders. Though Mr. Horneman resided in this place for several months, he has given no description of it as a city. Its inhabitants carry on no manufactures, and produce no other handicrafts but those of smiths and shoemakers. They are remarkable chiefly for their drunkenness and lewdness. For an account of the country and people, see Fezzan.

MOZART, John Chrysostom Wolfgang Theophilus, a celebrated composer, was born at Salzburg, in Bavaria, on the 17th of January, 1756. From the earliest age he testified the strongest predilection for music, which induced his father, who was organist of the prince's chapel, to discontinue the instruction of others, in order to devote himself to his tuition, and that of a sister, about four years older. After learning the harpsichord during a year, the flights of his genius were so rapid, that he exercised his own invention in original compositions at the age of only five, and attempted notation, which could be hardly decyphered. Being carried to Munich, along with his sister, both of them performed before an audience at Bavaria, and also in presence of the Emperor, Francis I. at Vienna, with equal approbation.

In 1763, Mozart publicly performed a conçerto on the violin at Munich; and having exhibited his talents in different towns of Germany, he was carried to Paris, where he played the organ of the king's chapel before the French court. An engraving of him, in which both his father and sister are introduced, was published in this city in 1764, describing him "composer and master of music, aged seven years." Mozart next reached London, where he excited great admiration: And doubts being entertained whether his real age was not disguised under a juvenile appearance, Mr. Barrington obtained a certificate of his birth by means of the Bavarian ambassador. It was proved by experiment, that he actually understood composition as a science; and at a concert given by himself and his sister, all the symphonies performed were his own. Precocious children have appeared in Britain, both before and since that period, as Dubourg and Clegg, performers on the violin, and Kruntzen on the harpsichord, of an earlier date; and in later times, Pinto, Gattie, and Miss Treemearn, who, at eight or nine years old, played a violin concerto in Covent Garden Theatre, in 1817. Mrs. Billington's talents, also, were exhibited at the age of seven, and in her eleventh year she played a concerto composed by herself. Some of these had greater difficulties to execute; but none, except Mozart, was born a musician, whose skill in the science was enlarging gradually until the last hour of his existence. The family returned to Salsburg in 1766.

The two young musicians performed in the presence of the Emperor, Joseph II. at Vienna, in 1768, when Mozart was commanded by that sovereign to compose the music for a comic opera, which was approved, but never brought out. When only twelve years old, however, he composed and directed the performance of a mass for the dedication of a church. He was accustomed at this time, on receiving an air in company, to set parts to it without retiring.

Mozart next visited Italy, where he experienced the most flattering reception; but the Neapolitans insisting that there was some hidden charm in a ring which he wore during his performance, he removed it, to show there was none. He was elected member of the Philharmonic society of Bologna, and received an order of knighthood from the Pope. A mass called the *Miserere* is performed at Rome, in the Sixtine chapel, twice during Passion Week, by choristers only, with an effect which no other band has been able to produce, insomuch that Leopold I. of Austria having obtained a copy from the Pope, he suspected a spurious composition had been imposed on him, and sent an envoy to remonstrate with his Holiness. The musicians being prohibited to give copies of it, Mozart, by an astonishing effort, committed the whole to memory; he wrote it down at home, after the first performance, and on the second occasion carried it in his hat for correction.

Having previously undertaken to compose the music for a serious opera, to be produced at the carnival of Bologna, he wrote Mithridates in his fifteenth year, which was performed on twenty successive nights; and during four or five years, partly occupied in excursions throughout Italy and Germany, he engaged in several works at the desire of illustrious personages. His parents constantly accompanied him in his travels, for he was so completely devoted to his art as to be regardless of all personal interests.

In 1777, Mozart intended to establish himself at Paris, a plan from which he was diverted by his disapprobation of the kind of music which was fashionable in that city.

After returning to Salzburg in 1779, he resolved to fix his future residence in Vienna, where it is affirmed that he became the pupil of Haydn. We are doubtful of the fact, but this master held him in high estimation; and it is known, that a few years later he did not scruple to affirm that he was the greatest composer of the age.

For a number of succeeding years, Mozart did little else than compose music with amazing reputation; he was powerfully promoting that grand revolution which was substituting energy, variety and expression, for the languor and monotony which pervaded the works of most of his predecessors. His operas, symphonies, quartetts, songs, and dances, were all received with unexampled avidity. But the period when he became passionately enamoured of Constantia Weber, a celebrated actress, was not the least brilliant of his compositions, for it is under such impressions that men are most earnest to distinguish themselves. Tenderness is the leading characteristic of his works, and he had now an opportunity of displaying all his science and feeling in an opera, called *Idomeneo*, which, in the year 1781, had been demanded from him by the Elector of Bavaria. Mozart was wont to esteem it the best of his productions, along with *Don Juan*, an opera of another kind. The success of the latter, which was composed for the theatre at Prague, in 1787, was more equivocal. Though the work had been undertaken for a considerable time, Mozart, instead of fulfilling his engagements, had spent the day preceding that for which the performance was announced in hunting, for he was immoderate in the pursuit of pleasure. The general rehearsal had taken place, but the overture was yet to be written. After partaking of some exhilarating beverage, he sat down to finish his task, when, overpowered by fatigue, he soon fell fast asleep. His wife allowed him to repose two hours, and having awakened him at five in the morning, he completed the work, which was heard in the evening. Critics pretend that the parts where the composer's faculties were overcome, are betrayed in the composition; and certainly the first movement contains passages from which earlier musicians would not have earned fame. Don Juan, now better known by the name of Don Giovanni, was not performed in the Opera House, London, until 1817, thirty years after its date. Here, it may be remarked, that Mozart's habits were very irregular. At times he laboured with incredible application, and would instantly commence the subject of an engagement, but he was not equally assiduous in completing it. He generally composed early in the morning; after which he did nothing during the day, unless it might be adding to works in progress; he was also fond of playing late in the evening, and would pass entire nights with the pen in his hand. In consequence of his habits, and the uncertainty of his profits, as also his generous disposition, Mozart's finances became so much deranged, that about this time he proposed to reside in London.

Before the period of which we speak, however, he had composed a comic opera, *The Elopement from the Seraglio*, by command of the emperor Joseph II., and *The Marriage of Figaro*. On the rehearsal of the former, the emperor, who himself had considerable skill in music, said to him, "My dear Mozart, that is too fine for my ears: there are too many notes in it." "I ask your majesty's pardon," replied the composer, not relishing the criticism, "there are just as many notes as there should be." The emperor was embarrassed, and remained silent. Perhaps Mozart afterwards admitted the justice of the remark, for the opera underwent many retrenchments and alterations. The extension of the scale, and multiplication of musical intervals, constitute a leading distinction between the older and modern composers. Both may be carried to infinity; but as that alone can be called music, from which pleasure is immediately derived, the advantage is not obvious of descending so far, that nothing except a confused flutter is sensible to the ear, or of ascending so high, that the powers of vibration seem exhausted in piercing shrillness. Considering, also, that the finest airs are restricted within a very narrow compass, it is evident that the multiplication of the notes in a bar, until there seems a contest between number and space, and the minuteness of their subdivision, are often of very questionable application. When the opera to which we allude was publicly performed, it received the warmest encomiums from the emperor, with whom Mozart was a great favourite, though without participating much of his bounty. He had been appointed chapel-master to his illustrious patron, to which office no salary was attached, but he received 100*l.* a-year as private composer to him. However, he was attached to his person, and on that account declined an offer of being appointed director of the orchestra of Frederic of Prussia, the sovereign who best of all knew how to appreciate merit.

The production of an opera being an incident of notoriety, to which many have an interest in calling the public attention, the date of other compositions is not so readily ascertained. Mozart wrote a number of pieces merely to gratify his friends, which were afterwards surreptitiously obtained by music-sellers for publication. But copyrights on the continent are less valuable than in Britain, where indifferent ballads are remunerated with ten guineas each, and the music for dramas with 1000*l.* or 1200*l.* Mozart received about fifty guineas for the *Magic Flute*, one of his finest works, and the favourite composer of modern times, Rossini, does not reap more than 50*l.* for a whole opera.

The *Magic Flute* was composed in 1792, and was performed an hundred times at Vienna in the course of a year. But Mozart had frequently to contend with distressing opposition to his works, in the jealousies excited against him among those whom his celebrity eclipsed, and to which he himself believed he at last fell a sacrifice. On the first representation of the Marriage of Figaro at Vienna, some of the principal performers endeavoured to diminish the effect of the finest airs; which so much provoked the composer, very irritable, besides, in musical matters, that he loudly complained to the emperor, then present, who threatened the offenders with his displeasure. In fact, the greater works of Mozart can admit of no diminutions. For the performance of Haydn's *Creation*, it has been remarked that "at least twenty-four voices and sixty instruments are required:" and of Mozart's operas it may be said, that not only the orchestra must be full, but the performers excellent, conditions so rarely attainable, that it is not surprising if a manager, exhibiting his theatrical library, exclaimed with a deep sigh, on pointing to the shelves bearing his name, "These have been my ruin." From this defect they have repeatedly failed.

Independent of our inability to trace the progress of Mozart's works, all have been reproduced under such diversified forms, that it is no easy matter to discover either for what instruments, or for how many parts they were designed originally. But the fertility of his genius embraced every different department of the art; and the period when it was most active can be sometimes ascertained. The rapidity of his composition was astonishing, for *La Clemenza di Tito*, an opera demanded by the Bohemians for the coronation of Leopold II, was begun in his carriage, on a journey to Prague, and finished in 18 days. But already Mozart's health was declining; his anxieties became great, and his application immoderate. Totally absorbed by enthusiasm, he neglected repose, and frequently he fainted from the excessive fatigue attending the ardent prosecution of his labours. At length he fell into a habitual melancholy, from which nothing could arouse him, and he was full of terror at his approaching end. The fatal event, however, was accelerated by a circumstance well calculated to make a deep impression on the morbid sensibility of his mind. When plunged in a profound reverie, a stranger of dignified manners was announced, who communicated the wishes of some unknown person of exalted rank, that he should compose a solemn mass for the repose of the soul of one tenderly beloved, whom he had just lost. An air of mystery pervaded the interview: the composer was exhorted to exercise all his genius; and he engaged to finish his work in a month, when the stranger promised to return. He disappeared, and Mozart instantly commenced writing. Day and night were uninterruptedly occupied: but he was consumed by gloomy presages, and at length exclaimed abruptly to his wife, in great agitation, "Certainly I am composing this requiem for myself:—It will serve for my own funeral."

Though his strength continued to fail, his assiduity was unabated; and at length he was obliged to suspend the undertaking. At the appointed time the stranger returned. "I have found it impossible to keep my word," said Mozart: to which the stranger answered, "Give yourself no uneasiness. What longer time do you require?" Mozart replied, "Another month."—The stranger now insisted on doubling the covenanted price, which he had paid down at the outset, and retired. It was in vain that Mozart endeavoured to trace him; which, conjoined with other circumstances, corroborated his belief that he was some supernatural being, sent to announce the close of his mortal career. Nevertheless, his labours were renewed; and the work at last was nearly completed within the stipulated period, when the mysterious stranger again returned; but Mozart was no more. He died on the fifth of December, 1792, aged thirty-five years.

In person Mozart did not exceed the middle size; he was thin and pale, and his health was always delicate. The expression of his countenance, without any thing striking, was exceedingly variable, and rather that of an absent man. His habits were awkward, and his hands had been accustomed so incessantly to the piano, that they seemed incapable of application to any thing requiring address. He was of a mild and affectionate disposition: his mind was not uncultivated, and the number of his works is a sufficient proof of his industry. His opinions of other composers were liberal, and he entertained the highest respect for Haydn in particular. "Believe me, sir," said he to an officious critic, who sought to demonstrate certain errors of that great master, "believe me, sir, were you and I amalgamated together, we should not afford materials for one Haydn." He was not insensible of the beauties of his own compositions; and on the very day of his decease, calling for the *Requiem*, he had some parts of it performed by his bedside. As the stranger who received this fine work could never be discovered, notwithstanding all inquiries, it would have been lost for ever, but for the preservation of the score by the composer's family.

The genius of Mozart in music was sublime. By the number, variety, combination and effect of his works, he ranks in the highest class of modern masters. An air of delicacy and sentiment pervades the whole. Full and harmonious, they are altogether free of that meagreness, and those capricious eccentricities, which betray the sterility of invention too common among musicians. The taste which they exhibit shows that vulgar images were incompatible with his mind; it seems as if he knew that such a deformity is alike pernicious to science and the arts. A vulgar composer is struggling to carry mankind back into the path which they have left far behind them; a polished composer, in outstripping his contemporaries, lays open a beautiful field, which he invites them to enter. Mozart has been most successful in gloomy passages, or those of rising grandeur, from according better with the ordinary train of his feelings. On almost all occasions he is more serious than comic, in endeavouring to pourtray the passions; and his love, it has been remarked, is rather sentimental than sportive. However simple the theme, however intricate its variations, his return is always natural, and the close appropriate. Perhaps the celebrity of Mozart's music partly arises from the skilful management of his closes; for they invariably leave an agreeable impression. No one has surpassed him in the suitable occupation of the parts of his concerted pieces; for, understanding the precise qualities of every different instrument, nothing is appointed to any which is inconsistent with its character.

Notwithstanding the excellence of this composer's works, he is charged with some important defects, though it must be admitted that there are fewer inferiorities than in the same number produced by any other. His vocal performers, it is alleged, are sometimes treated as if they constituted part of the orchestra. In passages and intervals of great difficulty they have to contend against the overpowering effects of the wind instruments, whence his operas have frequently failed even with good companies. Neither can it be denied, that nearly all the subjects of all his symphonies want that interest which characterizes those of Haydn, that they are noisy, thus participating of the grand fracas of instruments, wherein the Germans seem to place their chief delight; and what is more singular, that none of them command the attention of an audience. Undoubtedly his quintetts, quartetts, and piano-forte compositions are very fine; yet they are less interesting to the hearer than to the performer. Their recondite properties are perhaps too slowly unfolded for a transient performance; but, for the same reason, their subsistence should be more permanent, as that which becomes familiar soon loses its charms. In the vocal department, however, Mozart has certainly excelled Haydn. Here he has profited by a precept of that inimitable master, who himself, by a strange inconsistence, appears to have transferred it from the voices to the instruments. "Let the air be good," said Haydn, "and the composition, whatever it is, will assuredly please. It is the soul and essence of music."

In contrasting the merit of composers, their æra is to be taken into account. Handel, though born only 30 years later than Corelli, aimed at effects which the other never conceived, and quite disconcerted him by his novelties. The youth of Haydn was cotemporary with Handel's age. Mozart followed, and both have executed what it is doubtful whether Handel ever contemplated. Descending still later, the works of Beethoven seem to exceed the views, but we shall not say the qualities of all his predecessors. Neither is the structure of the orchestra to be overlooked, for, independent of the combinations of musical phraseology, the subdivision and extension of the scale, it is there that we must also seek much of the varieties of modern music. Every theme being simple in itself, the older composers retained that simplicity; their vocal parts had few accompaniments, but the moderns cultivate the highest embellishments of the voice, while they sometimes forget its right of predominancy amidst contending harmonies. The instruments were few, and of very limited compass, and the essence of the composition was restricted to the hands of the leader. Now they are multiplied, the scale is enlarged beyond all the bounds of emphatic expression, and the finest passages of the music are dispersed every where; thus producing greater variety, which requires greater address. Corelli's pieces, excluding the organ *ad libitum*, have no wind instruments: Handel in general uses them sparingly: but Haydn does not scruple to give the hautbois or bassoon a solo: Mozart frequently calls on the pre-eminence of the flute: Cherubini displays the bass; and, as if all the powers of melody were exhausted, Beethoven finds a wide vacancy for kettle-drums. Perhaps the roundness and fulness so peculiar to some of this author's works, results merely from the more copious use of graver intonation. Composers also, not content with imitative, have attempted descriptive music, as if, from the faint resemblance which may be produced of the roll of distant thunder, it were equally possible to represent the flashing of lightning, or the shock of an earthquake. But no descriptive or imitative music has yet betrayed its original: on the contrary, the composer is chiefly indebted to the pliant imagination of his audience, coupled with pointed verbal explanations. On the whole, we are inclined to rank Mozart next to Haydn.

Like most other great composers, Mozart probably has written too much. Many men mistake fertility for invention; but the real brilliance of original genius is soon exhausted, and on this account it is that, in the vain pursuit of novelty, they wander into inconsistencies, which, although a temporary support, are ultimately fatal to their works. The total number of Mozart's compositions, we have understood, amounts to 115, among which are 12 dramatic operas, 17 symphonies, 6 original quintetts for violins, tenors and violincello, 10 quartetts, and 1 trio for the same instruments, together with 2 duetts for violin and tenor. He wrote many pieces for the piano, and all other instruments; but several changes have been made in the arrangement of his music, both by himself and its editors. One of his piano-forte quartetts was a quintett, and one of his violin quintetts originally adapted for eight wind instruments.

Mozart married Constantia Weber in 1781, by whom he left a son and a daughter. After his decease, his family met with ample protection and support from the inhabitants of Vienna, who were grateful for the pleasure they had derived from his works. His sister abandoned the musical profession on marrying a counsellor of the Prince, bishop of Salzburg. It is said, that his son, following in his footsteps, has composed between 15 and 20 operas, chiefly for the piano-forte, but without gaining equal celebrity. (*c.*)

MULL, one of the western islands of Scotland, is in the county of Argyle, and is the third in point of magnitude. It is of a very irregular form, and so much invaded by arms of the sea, that its circumference is above 300 miles, although its greatest diameter does not exceed 35. It is divided into three parishes, Kilfinichen, Kilninian, and Torosay; of which the following was the population in 1811.

Kilfinichen,	3205
Kilminian,	4064
Torosay,	2114
Total,	9383*

The superficial contents of the island are 420 square miles, or 210,000 Scotch acres.

The parish of Kilfinichen, generally called the parish of Ross, occupies the south-western part of the island, and extends 22 miles in length, and 12 in breadth. It includes the islands of Inchkenneth, Eorsa, and Icolmkill. It is in general barren and mountainous. The shores are bold and rocky, exhibiting in many places basaltic columns; and there are good marble quarries in different parts of the parish. The kelp made annually varies from 70 to 120 tons.

The parish of Kilninian occupies the peninsula in the north-west part of the island, and extends about 12 miles in length, and 12 in breadth. It includes the inhabited isles of Ulva, Gometra, Little Colonsa, and Staffa, and the uninhabited cluster called the Treshinish Isles. The parish is in general hilly; but the arable land on the coast is tolerably good and fertile. This parish manufactures from 170 to 180 tons of kelp annually, at the expense of about 30s. per ton. There are five lakes in the parish, abounding with trout. Salmon are caught at the mouth of several of the rivulets. The town and harbours of Tobermory and Aros are in this parish.

The parish of Torosay, or Pennygown, occupies the south-east side of the island, and stretches along the sound of Mull. It is about 12 miles wide in every direction. Its general aspect is rugged and mountainous. The highest part of it, viz. Benmore, is 3097 feet, as determined barometrically by Dr. Macculloch, while Benychat, the highest hill next to it, is 2294. The parish is excellently adapted for sheep pasture. Castle Dowart, once the residence of the chief of the Macleans, stands on a lofty promontory, overhanging the Sound of Mull, and, till lately, was occupied as barracks for a small party of soldiers from Fort William, stationed here to check the smugglers. The parish contains several birch woods, annually cut for charcoal. There are some red deer in the mountainous parts of it.

The Duke of Argyle is the principal proprietor in Mull, the number of proprietors amounting to about 10. The Duke possesses nearly one half of the island.

The climate of Mull is remarkable for its extreme wetness. It is more subject to rain than any of the western islands, exceeding even in this respect Rum or Sky, which rank next to it. Dr. Macculloch ascribes this to the altitude of its own hills, and to that of the range which extends from Cruachan to Ben Nevis, which assists in precipitating the clouds that arrive from the western ocean. From its being immediately open to the sea, it receives with undiminished energy gales of wind

* Dr. Macculloch, in 1819, estimates the population at ten thousand.

and rain, of which the inhabitants of better climates can scarcely form a conception.

The principal town and harbours in Mull, are Tobermory and Aros. Tobermory (St. Mary's Well) was begun in 1789, under the auspices of the Society for the Encouragement of Manufactories and Fisheries. A custom-house and post-office were built in 1791, and many good houses of stone and lime, and covered with slate, have been since erected. It has of late increased in population, and now contains about 600 inhabitants. It has a fine bay and harbour, sheltered from the ocean by the Isle of Calve. It had, in 1810, 11 registered vessels, manned by 29 men, and amounting to 278 tons burden; and there are, besides, 28 open boats, with three men each, which are commonly employed in the fishery. The village has therefore 113 seamen. In 1808, the number of vessels which entered inwards was 58, and those which cleared out 70. There is also a harbour at Aros, and near it a picturesque old castle, which is said to have belonged to the Lord of the Isles. The castle of Moy, situated in Loch Buy, is another of the antiquities of Mull. It is very entire, and forms a fine contrast with the modern excellent mansion-house which stands near it. See M'Donald's *Agricultural Survey of the Hebrides*, p. 669. Edin. 1811; Smith's *Agricultural Report of Argyleshire*, Lond. 1813; and Dr. Macculloch's *Description of the Western Islands*, vol. i. p. 530, 537, and vol. iii. p. 73. Edin. 1819.

MULTIPLIER. See ELECTRICITY.

MUMMY. See EMBALMING.

MUNDEN. See MINDEN.

MUNICH, the capital of the kingdom of Bavaria, is situated in a plain on the west bank of the Iser. It is surrounded with a rampart, which incloses three-fourths of the houses, the other one-fourth constituting the suburbs. Munich is divided into four quarters by means of two spacious streets, at right angles to one another, the place of intersection forming the principal square. The streets are in general broad, and the houses neat and well built, though high. The principal public building is the palace, which, though plain in its exterior, is within splendid and magnificent. It contains a grand saloon, called the White Horses; the grand imperial hall, which is reckoned the finest in Germany; the cabinet, adorned with 130 miniatures, each of which is valued at 200 old Louis; the bed of Charles VII. the embroidery of which, in gold, silver, and pearls, weighs 24 quintals; a tapestry, representing the actions of Otho of Wittlesbach; the great marble staircase; the gallery of pictures; the treasury, containing a large collection of diamonds, rubies, emeralds, &c.; the royal chapel, with its valuable deposits, such as a virgin of gold, weighing 22 lbs., a superb picture of Michael Angelo, and the small altar which Mary, Queen of Scots used in prison; a fine organ, the famous palatine pearl, and the model of Trajan's column, which cost 10,000 ducats, the ground being of lapis lazuli, and the bas relief in bronze. It was executed in 1780 by Livadier, and the bas reliefs by Bartolom.

The principal church of Munich is that of Notre Dame, which contains the monument of the Emperor Louis IV. besides thirty altars, and paintings of great value. The church of the Theatins, built on the model of the Vatican, contains a fine painting of the plague at Naples, by Sandrat. The church of the Augustins has a fine painting by Tintoret, which was cut in two in order to get room to snuff the candles. The other principal churches are, that of the ci-devant Jesuits, now belonging to the Knights of Malta; the church of St. Peter, adorned with fine paintings: that of the Knights of Malta, containing a treasure worth two millions of florins; and that of the English religious, who instruct young girls gratis, not only in religion, but in objects of useful industry. Munich contains, altogether, twenty-two churches. The other public buildings are, the old electoral palace; the palace of Prince Eugene Beauharnois; the Jesuits' college, containing several saloons, in one of which the academy of sciences holds its sittings, while another is occupied with physical and mechanical instruments and models, and objects of natural history; the convent of the Franciscans, which contains a fine copy of the last judgment, by Michael Angelo; the land-haus, where the states meet; the council house; the arsenal; the new opera house; the barracks; the mint; the hospital of St. Esprit; the great military garden.

The principal literary and useful establishments are, the academy of sciences, established in 1759; the school of design; the military school; the lyceum; the gymnasium; the seminary for training teachers; the observatory; and the veterinary and surgical schools; the house of industry, and the house of education, both of which were established by Count Rumford; four orphan houses; a lock-hospital, and a house of correction. The principal libraries are those of the king, the Jesuits, and the academy of sciences. The royal library contains more than 100,000 volumes, and possesses a great number of editions of 1400, and some valuable MSS. The first edition of Ptolemy, with maps, is one of the rarities in this library.

Munich carries on very considerable trade in grain, wood, salt and iron. Its principal manufactures are, the royal one of tapestry, one of silk ribbons, gold and silver lace, cotton stockings, piano-fortes, playing-cards, tobacco, beer, which is made to the annual value of a million of florins, porcelain made at Nymphenberg, and brought to the warehouse at Munich.

The environs of Munich are beautiful and agreeable. The king has three royal residences, viz. at Nymphenberg, Schlosheim, and Furstenried. At Nymphenberg, about 1½ miles from Munich, are large gardens and water-works, but the palace is a tasteless mass of buildings, built on the plan of Versailles. The palace of Schlosheim, 12 miles from Munich, is a magnificent building, and contains 300 apartments. The gallery of paintings, for which it was once famous, were removed about 40 years since to Munich, and have been replaced by others. The population of Munich is estimated at 48,000. East Long. 11° 34′ 30″, and North Lat. 48° 8′ 20″. See Kuttner's *Travels*, Lett. xxvi.; Reichard's *Guide des Voyageurs en Europe*, tom. ii. p. 118; and *Abrégé de tout ce qu'il y a de remarkable à voir à Munich*, 1790. Par. L'Abbé Bermiller.

MUNSTER, a town of Prussia, and principal place of a government of the same name, is situated in a fertile and agreeable plain on the river Aa, about six miles from the Ems. The town is tolerably built. The houses in the chief streets have colonnades, and are generally lofty and irregular, with painted roofs. Munster possesses eleven churches, the principal of which are the cathedral, and the church of St. Lambert. In the former is the remarkable chapel of Bernard de Galen, and several ancient monuments; and at the top of the tower of St. Lambert's are still seen the three iron cages in which were suspended John of Leyden, the king of the Anabaptists, and his two chief abettors. The episcopal palace is a neat building, with extensive and beautiful gardens. Munster has three schools for the education of youth, who pursue their maturer studies at the university of Bonn, established in 1818. A small trade is carried on in linen, woollen, wine and grain, and there are some small manufactories of coarse linen. The ramparts are flanked with trees, and form a beautiful promenade. The population was formerly 25,000, but it is now stated at 13,000. East Long. 7° 36′ 21″, and North Lat. 51° 58′ 10″.

MURCIA, a province in Spain, on the shores of the Mediterranean, extends above 30 leagues from north-west to south-east, and 20 from the south-west to the north-east. It is a dry hilly country, almost covered with mountains, which are chiefly branches of the Montes Orospedani. The most remarkable of these, in extent and elevation, is that of Carascoy, to the south-east, a continuation of the Sierra de Cazoila, which stretches also into Jaen on the south, and into Granada on the north. None of these hilly regions are cultivated, though the soil is well suited for vines and olive trees. The mountains of the province have the appearance of containing many valuable mineral productions; and there are traces of lead, copper, alum, sulphur, and silver mines. Feathered alum, or false asbestos, is found near the village of Almanzarron; rock-crystals on two mountains near Carthagena; a large salt pit near Villena; and various kinds of marble, particularly on a lofty ridge towards the frontiers of Granada on the north-east. There are hot mineral springs in several places, which are used in paralytic and rheumatic disorders, especially one at Archena, four miles from Murcia, which was much celebrated under the Arabs, and where ruins of Roman edifices have been discovered.

There are only two rivers in the province, the Segura and the Guadalentin; and the last of these is little more than a brook. The climate is remarkably temperate, except in the neighbourhood of Murcia and Carthagena, where the heat is almost insupportable in summer. The sky is uncommonly serene and clear; and rain falls very rarely in any part of the province.

The soil is generally dry, but a little rain has great efficacy in the more parched plains. In the watered plains, along the banks of the Segura, it is uncommonly fertile; but, except a few olives and mulberries, there is nothing but corn raised upon them. The soil, in general, requires little cultivation, and wherever irrigation can be practised, yields the most abundant returns; but the inhabitants have no skill in agriculture, and are too indolent to avail themselves of the advantages within their reach. Except around the principal towns, where the grape is cultivated, and wine made, little else is raised in the province but corn, chiefly wheat, rye, and barley. A considerable quantity of Spart, or Spanish broom, is still cultivated near Carthagena, for making shoes; but in the time of the Romans, the country was so covered with it, that Pliny says it furnished the common people with materials for making bedding, clothes, shoes, and fire. Hemp is cultivated in the watered plains: saffron is raised in some places; and olive oil, though of an inferior quality, is made in considerable quantity. But next to wheat, the most valuable produce of the province is silk, for which the white mulberry trees are every where cultivated, and of which about the value of 260,000*l.* is annually prepared. The whole produce of the province is estimated at 1,436,875*l.* There are few manufactures in the province; and even the greater part of the raw silk prepared in the country is sold to the neighbouring provinces, while manufactured silk is imported from other places. It is only in the town of Murcia that a manufactory of silk and ribbons is carried on to any extent. Soap is made at Villena and Murcia; hardware at Albacete; brandy at Sar and Villena; salt-petre and gunpowder at Murcia; and spart is made in private houses into shoes, mats, baskets, cordage, and package coverings.

There is little inland commerce in the province, as the roads are generally in a very bad state; and there are few commodities to support a foreign trade. The exports are cutlery, ribbons, worked spart, wine, silk, grain, kali, saffron, to the amount of 493,038*l.* annually; and the imports are fruits, beef and mutton, wines, spices, linens, cloths, silk stuffs, hardware, and a few articles of luxury. But the balance is in favour of the exports, which brings some wealth into the country every year.

There are no inns in the province, except in the towns of Murcia and Carthagena; and the posades are very bad. Coaches, calashes, and volantes, are used in travelling; and there are various little carts and waggons, drawn by mules or oxen; but asses are principally used in carrying burdens. No attention is paid to the arts and sciences in the province. There are no artists, nor even a tolerable workman in the whole of it. Except at Carthagena, where the institutions for education are confined to the pupils for the royal navy, there are only a few miserable schools kept by monks. There are two public libraries in the town of Murcia; but few persons make any use of them. The principal towns of this province are, Murcia, Carthagena, Lorca, Jumilla, Albacete, Almanza. The country is thinly inhabited, except in the more fertile plains, where the villages are closely crowded. The population is not above one-half of what it might contain; and in 1788, did not exceed 338,000.

The natives of this province are remarkable for their apathy and indolence. They seldom remove from their native spot, to enter the army, the navy, or the universities. The more wealthy individuals spend their whole time in eating, sleeping, or smoking cigars. The shopkeepers, the mechanics, and even the peasantry, are constantly retiring to their meals, or their repose, and do not employ a quarter of the day at their work. Even the domestic servants, in the summer season, when it is easy to procure subsistence, leave their places, and refuse to labour when they can live without it. They are indifferent even about walking abroad for recreation; and either spend their days within doors, or sit down if they come into the open air. They seldom visit one another's houses, nor take any part in amusements, nor bestow any attention on dress and furniture. It is only in Carthagena that the inhabitants show any activity, affability, or enjoyment; but these are chiefly foreigners, collected in the place for the purposes of trade. See Laborde's *View of Spain*, vol. ii. (*q.*)

MURCIA, the capital of the above mentioned province, is situated on a level spot in a large and beautiful valley, watered by the Segura, and ornamented by extensive plantations of mulberry trees. It does not appear to have existed in the time of the Carthaginians or Romans; and is first mentioned about the end of the Gothic dynasty in Spain. It is frequently noticed in history after the beginning of the eighth century, as alternately subject to the Caliphs of Cordova and the kingdom of Granada; and it was not till 1265 that it was taken possession of by Alphonso X. King of Castile.

The most ancient families in the place are of French origin; and still bear names which indicate their descent from that nation. Murcia was formerly a fortified city; and some remains of its walls and towers are still to be seen. The streets are very narrow, irregular, winding, and badly paved. The houses are ill built, and very few of them are worthy of notice. Many of them are of ancient architecture, and loaded with ornaments of sculpture, in a bad taste, and of poor execution. There are no public edifices, except the churches; some of which have a good appearance, and the cathedral particularly, though ill proportioned, and awkwardly designed, exhibits many architectural ornaments, and contains a number of paintings. There are several promenades, and a botanic garden, capable of much improvement; but the citizens seldom frequent any of these places of exercise and recreation.

There are manufactories of salt-petre and gunpowder in the town, on the king's account; and others of earthen-ware, silk twist, silk stuffs, spart, and ribbons; and the principal commerce of the place consists in exporting the two last mentioned articles to Madrid.

It is the see of a bishop, whose diocese includes almost the whole present kingdom of Murcia, and who enjoys a revenue equal to 22,916*l.* 14*s.* 4*d.* The town contains eleven parishes, and a population of 60,000 inhabitants; which includes, however, the inhabitants of the adjoining plain, who may amount to one-third of the whole number.

Many noble Spanish families reside in the place; but the citizens in general spend their lives in sloth and indifference, and are totally ignorant of every thing beyond the boundaries of their city. They are of a yellow, sun burnt, and even livid complexion; a gloomy and choleric temperament. Their indolent habits, bad food, and excessive use of iced-water, renders them subject to ill health. The universal remedy employed by them is bleeding in the hand; and few of them are known, who do not lose blood ten or twelve time every year. See Laborde's *view of Spain*, vol. ii. (*q*)

MUREX. See Conchology.

MURIATIC ACID. See Chemistry.

MUSCA. See Entomology.

MUSCAT, Mascat, or Meschet, a city of Arabia Felix, situated at the entrance of the Persian Gulf, under the tropic of Cancer, and in 57° 26′ of east longitude. It is the most considerable town, though not the capital of the province of Omon; and the Imaum, or prince of the country, is usually styled the Imaum of Muscat. His dominions extend about 300 miles along the Persian Gulf, and nearly as far inland, till they touch the territories of the prince of Yemen. The town of Muscat is built on a level spot, between two rocky hills, on which are erected a number of well placed batteries, capable of making a formidable defence against any attack from the sea. The harbour, which resembles the figure of a horse-shoe, with the entrance at the south-east point, is remarkably well sheltered from the most prevailing winds, and so capacious, that several hundreds of ships might ride in it with perfect safety and convenience.

The Portuguese, after their expulsion from Ormus, took possession of this town in 1508; and besides strengthening its fortifications, adorned it with many public buildings. During a century and a half, they carried on a profitable trade with the Arabs for gums, drugs, hides, bees-wax, cattle, sheep, &c. in exchange for which they supplied them with tobacco, coffee, India and European goods. But about the middle of the seventeenth century, they were expelled by the Arabs; and all their attempts to regain possession of the place only served to improve the military and maritime power of the natives. The Muscateers carry on frequent hostilities with the Persians; but, at the very time when they would capture all ships of war and other vessels at sea, bound to other ports, they allow them free permission to enter the port of Muscat, or any of its dependencies, to purchase goods for ready money, and to pass safely homeward with their cargoes. So much of the patriarchal form of government is said to prevail in this city, that the Imaum is obliged to obey a summons before the Cadi, at the instance of any of his subjects, who might account himself aggrieved. The inhabitants are described as the most liberal minded of all Mahomedans, polite in their conduct to strangers, upright in their mercantile transactions, temperate in their mode of living, chaste in their manners, and rarely guilty of crimes requiring cognizance of the laws.

The climate of Muscat is extremely hot and dry. The rainy season extends from November to February; but heavy dews fall throughout the whole year, and supply the moisture requisite for vegetation. The mountains immediately behind the city are stony and barren; but the adjoining valleys are extremely fertile, and produce a variety of excellent fruits and grains. Wheat and barley are sown in December, and reaped in March. Oranges and lemons (supposed to have been introduced by the Portuguese,) grapes, apricots, and peaches, are abundant. The mango is produced in the greatest perfection; and their stones used to be carried to India for seed, as a better species than any to be found in that country. But the fruit most extensively cultivated, and for which the district is most celebrated, is the date, of which large cargoes are regularly exported. There is a great variety of excellent roots and pot-herbs; and sheep, cattle, and especially fish, may be purchased at a very cheap rate. Fresh water is conveyed to the shipping in a very peculiar manner. As the road from the spring is full of sharp rocks, and does not admit of casks being rolled along it, the water is carried down in skins, and emptied into boats constructed for the purpose; but these are sometimes apt to ship so much sea-water, as to spoil the whole cargo, or at least to render it unpleasantly brackish.

This town carries on a very extensive trade, and sends a number of large ships to the ports of the Red Sea, and on the coast of Malabar. The goods brought from these places are again transferred to trading vessels from both sides of the Persian Gulf, and from the coast of Caramania as far as the river Indus. The inhabitants also maintain a large inland trade, not only with the subjects of their own prince, but with numerous tribes of independent Arabs, to whom they send India piece-goods, pepper, ginger, rice, tobacco, coffee, sugar, with other kinds of India produce, beside English cutlery, cloth, toys, &c.; from whom they receive in return, gums, drugs, ostrich-feathers, hides, sheep and lamb-skins, honey, bees-wax, live cattle and sheep. The town is sometimes so full of goods, that the warehouses are not able to contain them; and they are said to remain night and day piled upon the streets, without any protection, and yet without any danger of being pilfered. Muscat has recently become a mart for importing slaves from Africa, who are thence shipped to Bushire and Bussorah. (*q.*)

GENERAL EXPLANATION

OF THE

PLATES BELONGING TO VOLUME THIRTEENTH

OF THE

AMERICAN EDITION

OF THE

NEW EDINBURGH ENCYCLOPÆDIA.

PLATES CCCLXXII, CCCLXXIII.

Contain Diagrams illustrative of the article Mensuration.

PLATE CCCLXXIV.

Fig. 1. A Thermometer with the Centigrade and Fahrenheit's Scale.
Figs. 2, 3. Represent the Self-registering Thermometer.
Fig. 4. Mr. Adie's Sympiesometer.
Figs. 5, 6. The Self-registering Hygrometer.
Fig. 7. A Pluvimeter, or Rain Gauge.
Fig. 8. Mr. Anderson's New Atmometer.
Fig. 9. Diagram for explaining the Theory of Rain.
Fig. 10. Diagram for representing Varieties of Temperature.

PLATE CCCLXXV.

Fig. 1. Cassini's Reticulum, or Micrometer.
Fig. 2. Dr. Bradley's improved Reticulum.
Fig. 3. Cavallo's Mother of Pearl Micrometer.
Figs. 4, 5. Dr. Brewster's Circular Mother of Pearl Micrometer.
Fig. 6. Prony's Nonius Screw for Micrometers.
Figs. 7, 8, 9, 10, 11. Diagrams, &c. for explaining and describing Dr. Brewster's Optical Wire Micrometer.
Fig. 12. Dr. Brewster's Eye-piece Micrometer for Refracting Telescopes.
Fig. 13. Dr. Brewster's Eye-piece Micrometer for Reflecting Telescopes.
Fig. 14. Diagram for explaining the principle of Divided Object Glass Micrometers.
Figs. 15, 16, 17, 18. Method of measuring Angular Spaces in the heavens by it.
Figs. 19, 20, 21. Dr. Maskelyne's Prismatic Micrometer.
Fig. 22. Ramsden's Catoptric Micrometer.
Figs. 23, 24. Ramsden's Dioptric Micrometer.

PLATE CCCLXXVI.

Figs. 1, 2, 3. Dr. Brewster's Divided Object Glass Micrometer.
Figs. 4, 5, 6, 7. Sir W. Herschel's Position Micrometer.
Figs. 9, 10, 11, 12, 13. Dr. Brewster's Position Micrometer.
Figs. 14, 15, 16, 17, 18. Sir W. Herschel's Lamp or Lucid Disc Micrometer.
Figs. 19, 20. Rochon's Doubly Refracting Micrometer.
Figs. 21, 22, 23. Dr. Wollaston's Single Lens Micrometer.
Fig. 24. Dr. Brewster's Micrometrical Comparer.
Fig. 25. Microscopical Micrometer by Double Refraction.

PLATE CCCLXXVII.

Figs. 1, 2, 3. Mr. Stephen Gray's Water Microscope.
Fig. 4. Mr. Gray's Fluid Reflecting Microscope.
Figs. 5, 6. Dr. Brewster's New Single Microscope.
Fig. 7. Dr. Wollaston's Periscopic Microscope.
Figs. 8, 9, 10, 11. Dr. Brewster's Improvements on the Periscopic Microscope.
Fig. 12. Common Flower and Insect Microscope.
Fig. 13. Microscope for Opaque Objects.
Fig. 14. Withering's Botanical Microscope.

Fig. 15. Pocket, Botanical, and Universal Microscope.
Fig. 16. Lyonet's Anatomical Microscope.
Fig. 17. Wilson's Pocket Microscope.
Fig. 18. Dr. Smith's Compound Microscope.

PLATE CCCLXXVIII.

Fig. 19. Cuff's Double Constructed Microscope.
Fig. 20. Universal Compound Microscope.
Fig. 21. Amici's Reflecting Microscope.
Fig. 22. Dr. Brewster's Reflecting Microscope.
Fig. 23. Mr. Waddel's Compound Microscope.

PLATE CCCLXXIX.

Fig. 24. Method of viewing and illuminating Microscopic Objects.
Fig. 25. Æpinus's Method of illuminating Microscopic Objects.
Figs. 26—33. Represents Martin's Solar Microscope, and the apparatus which accompanies it.
Fig. 34. Improvement on the Solar Microscope.
Figs. 35, 36, 37, 38. Represent Adam's Lucernal Microscope.
Fig. 39. Shows a new Method of illuminating objects in the Solar and Lucernal Microscopes.

PLATE CCCLXXX.

Fig. 1. Is the Lobster Insect, which is found on the Legs of a Fly, and also occurs in Books and Paper, and in Plants.
Fig. 2. Is an Insect denominated the *Thrips Physapus*, which is found on the Dandelion, and other Plants and Flowers. The body is black, and the wings white.
Fig. 3. Represents the *Cimex Striatus*, a beautiful Insect, with its colours very bright, and elegantly arranged. It is found in June on the elm-tree.
Fig. 4. Represents the *Chrysomela Asparagi*, which is found in June on the Asparagus, after it has run to seed.
Fig. 5. Is the *Meloe Monoceros*, found on umbelliferous Plants.
Fig. 6. Represents a Scale from the Sole Fish.
Fig. 7. Shows a Section of a Weed called the Fat Hen, which grows among rubbish.
Fig. 8. Is the Section of a Reed from Portugal.
Fig. 9. Represents a Section of the Bamboo.
Fig. 10. Is a Section of the Hazel.
Figs. 11, 12. Show the Eggs of Moths and Butterflies, particularly the *Phalæna Neustria.*

PLATE CCCLXXXI.

Fig. 1. Represents a Battalion forming Front to the Rear, by a Counter-march of the whole.
Fig. 2. Forming Front to the Rear by a Counter-march of Platoons.
Fig. 3. A Battalion forming Front to the Rear by wheeling about.
Fig. 4. One half faced to the Right-about, previous to Wheeling.
Fig. 5. Forming Front to the Flank, by facing to the Right or Left, and marching up.
Fig. 6. The same, by Deploying.
Fig. 7. The same, by a single quarter Wheel.
Fig. 8. The same, by an eighth Wheel, by Companies, the Flank Company only making an entire Wheel.
Fig. 9. The same, by wheeling round the Centre.
Figs. 10, 11. Forming from Line into Columns.
Fig. 12. Forming, or Deploying, from the Centre.
Figs. 13, 14. A Battalion in Column marching off to the Right and to the Left.
Fig. 15. Marching forwards in Columns.
Fig. 16. Marching to the Rear in Columns.

PLATE CCCLXXXII.

Fig. 17. A Counter-march by Columns.
Fig. 18. Columns breaking off on a narrow road, or defile, without halting.
Fig. 19. The Oblique March by Columns.
Fig. 20. Close Columns forming Front.
Fig. 21. Deploying from the Centre.
Fig. 22. The Movements reversed, the last Division forming the Head.
Fig. 23. Forming Front to the Rear by counter-marching and deploying.
Figs. 24, 25. Close Columns forming Front to the Flank.
Figs. 26, 27, 28. Columns formed by wheeling, placed in order of Battle to the Front.

PLATE CCCLXXXIII.

Figs. 29, 30, 31, 32, 33, 34, 35, 36. Columns forming Front to the Rear.
Fig. 37. Columns deploying close to a Defile.
Fig. 38. Passing Obstacles, and forming Line.
Fig. 39. The Oblique Order in Line.
Fig. 40. The Oblique Order by *Echellons.*
Fig. 41. An Army, in four Columns of March, forming Line.
Fig. 42. An Army attacked on its Flank, changing the direction of its Columns, and gaining the Flank of the Enemy.

PLATE CCCLXXXIV.

Represents the order of Battle at Kollin, between the Austrians and Prussians.

PLATE CCCLXXXV.

Represents the order of Battle at Rossbach, between the Austrians and Prussians.

PLATE CCCLXXXVI.

Represents the order of Battle at Leuthen, between the Austrians and Prussians.

PLATE CCCLXXXVII.

Fig. 1. Represents the order of March and Manœuvres at the Battle of Kollin.
Fig. 2. Represents the order of March at the Battle of Rossbach.
Fig. 3. Represents the order of March and Manœuvres at the Battle of Leuthen.

PLATE CCCLXXXVIII.

Fig. 1. Represents the way in which Strata of Coal meet the Alluvial Cover.
Figs. 2, 3, 4, 5, 6. Represent the Shapes of Coal Fields.
Fig. 7. Shows the Horizontal Section of a Coal Field intersected with Green-stone Dikes.
Figs. 8, 9. Represent Slips in a Coal Field.
Figs. 10, 12. Show the effects produced by Dikes.
Fig. 11. Shows the effects produced by Slips.

PLATE CCCLXXXIX.

Fig. 1. Explains the general Law respecting Dikes and Slips.
Fig. 2. Shows the effect of Hitches or Slips upon Strata of Coal.
Figs. 3, 4. Vertical and Horizontal Section of a Trouble, called a *Nip*.
Fig. 5. View of a Trouble called a Pot Bottom.
Fig. 6. Horizontal Section or Plan of a Coal Field as found immediately under the Alluvial Cover.
Fig. 7. Vertical Section of ditto.
Fig. 8. Shows the effect of a great Slip.
Fig. 9. Is the view of a Coal Field Basin.

PLATE CCCXC.

Fig. 1. Represents various Tools used in boring for Coal.
Figs. 2, 3, 4, 5. Explain the method of conducting a Series of Bores in exploring the Strata for Coal.
Fig. 6. Shows the method of ascertaining Edge Coals.
Fig. 7. A Coal Field where the Fitting is made by a Day Level.
Fig. 8. Represents a quicksand in a Day Level.
Figs. 9, 10, 11. Show the forms of Pits.
Fig. 12. A Bed of Quicksand resting on a Bed of Impervious Clay.
Fig. 13. Iron Gland for fixing Pumps in a Pit.
Fig. 14. Method of keeping back Feeders of Water.
Fig. 15. Represents a Pit widened for Plank Tubbing, or Cribbing.
Fig. 16. Method of wedging a Cutter in the Strata.

PLATE CCCXCI.

Fig. 1. Represents the method of Lowering the Pumps.
Fig. 2. Method of Tubbing and Cribbing.
Fig. 3. See p. 370 and 390.
Fig. 4. See p. 371.
Figs. 5, 6. See p. 372.
Figs. 8, 9. See p. 372.
Figs. 10, 11, 12. See p. 375.
Fig. 13. Shows a simple Mode of Working Coal.
Fig. 14. Shows one of the Shropshire Methods of working Coal.
Fig. 15. See p. 375.

PLATE CCCXCII.

Fig. 1. Represents Mr. Buddle's New System of Pannel working.
Fig. 2. Is one of the Shropshire Methods of working Coal.
Fig. 3. Is a Modification of the Shropshire Method.
Fig. 4. See p. 380.
Fig. 5. See p. 378.

PLATE CCCXCIII.

Fig. 1. Method of working the Shropshire Thick Coal.
Fig. 2. Method of working the Johnstone Thick Coal.
Fig. 3. Method of Working Edge Coals.
Fig. 4 Shafts or Limbers for Horses.
Fig. 6. Position of the Carbonic Acid Gas in Coal Mines.
Fig. 6 to 15. The various Methods of Ventilating Coal Mines.
Fig. 16. Position of the Inflammable Air in Coal Mines.

PLATE CCCXCIV.

Fig. 1. Represents Mr. John Taylor's Hydraulic Airpump.
Fig. 2. Shows Spedding's improved System of Ventilation.
Figs. 3 to 8. Shew the Methods of working Under-dip Coals.
Figs. 9, 10. Represent Dams for keeping back Water in Coal Mines.

PLATES CCCXCV, CCCXCVI.

Contain various Diagrams illustrative of the Principles of *Geology* and *Mineralogy*.

PLATE CCCXCVII.

Fig. 1. Represents a Side Elevation of Mr. Barton's Machine, as used at the Mint, for equalizing the thickness of Metal Plates.
Fig. 2. Is a Horizontal Plan of the same.
Figs. 3—6. Represent several of the Parts separately on a large Scale.

PLATE CCCXCVIII.

Fig. 1. Ocythöe cranchii.
Fig. 2. Two of the Corneous Rings of the Suckers of Loligo sagittata.
Fig. 3. Mandibles of ditto: a, the under one; b, the upper one.
Fig. 4. Pneumodermon peronii.

Fig. 5. Testacella haliotoidea.
Fig. 6. Onchidium typha.
Fig. 7. Doris marginata.
Fig. 8. Thethys fimbria.
Fig. 9. Phyllidia ocellata, upper side.
Fig. 10. Phyllidia trilineata, under side.
Fig. 11. Pleurobranchus membranaceus.

PLATE CCCXCIX.

Fig. 12. Bulla hydatis.
Fig. 13. Valvata cristata, magnified.
Fig. 14. Buccinum undatum, without the shell.
Fig. 15. Hyliotis tuberculata.
Fig. 16. Modiolus vulgaris.
Fig. 17. Synoicum turgens.
Fig. 18. Lingula unguis.
Fig. 19. Tubicinella balænarum.
Fig. 20. Coronula balænaris.

PLATE CCCC.

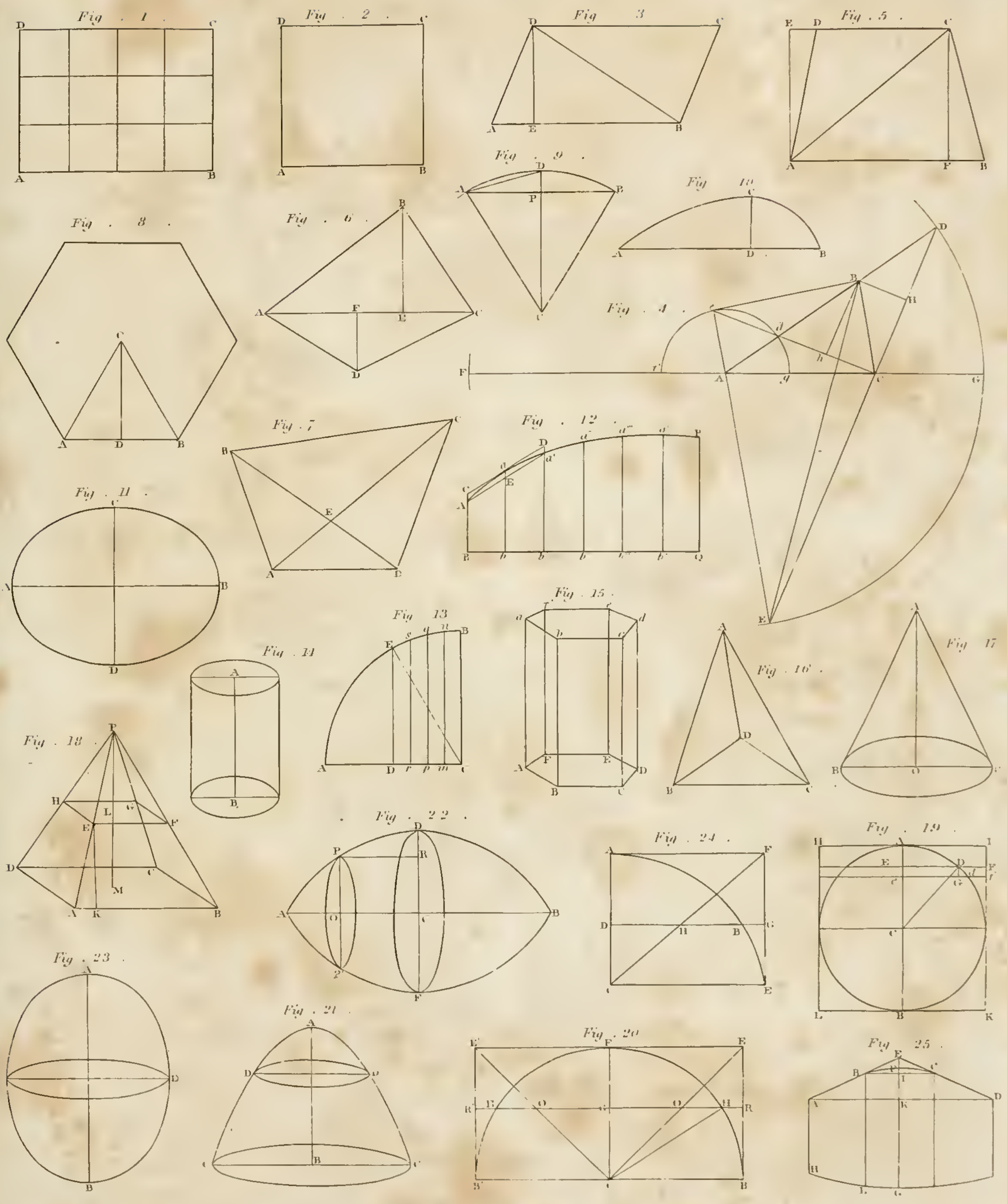
Is a Map of the Moon's Surface, from a drawing made by Dr. Brewster.

END OF VOLUME THIRTEENTH.

William Brown, Printer, Philadelphia.

MENSURATION.

PLATE CCCLXXII & CCCLXXIII.



METEOROLOGY. PLATE CCCLXXIV.

Fig. 1.

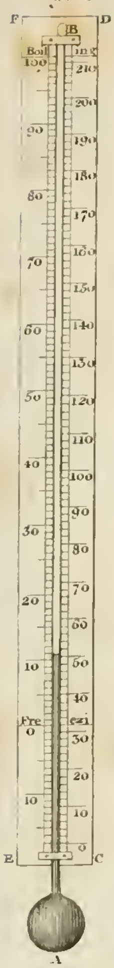


Fig. 2.

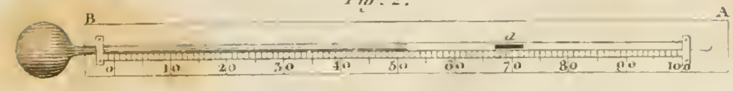


Fig. 3.

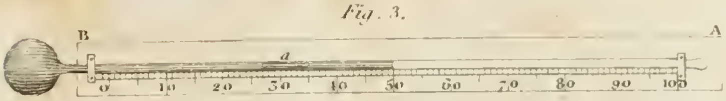


Fig. 4.

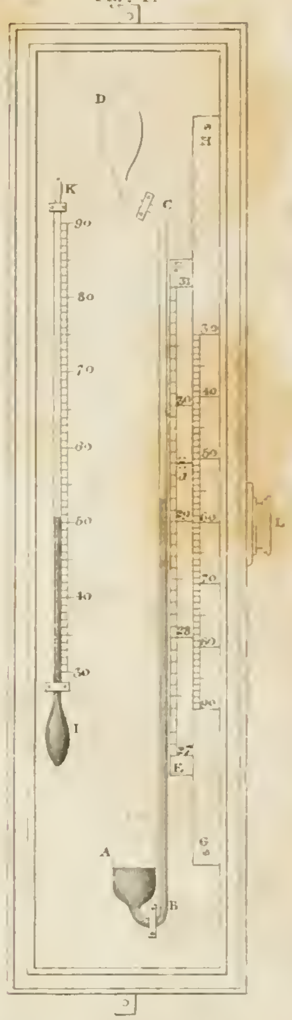


Fig. 5.

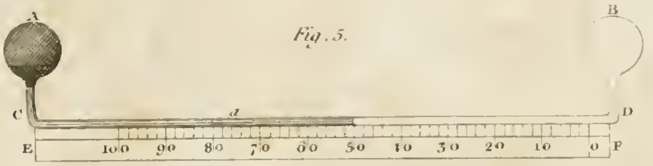


Fig. 6.

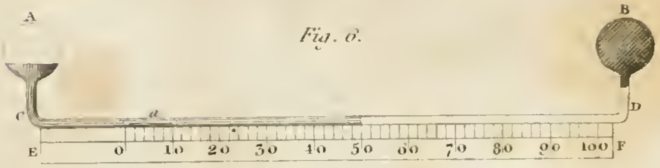


Fig. 9.

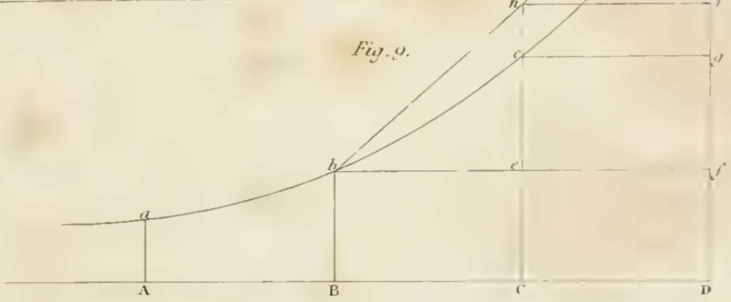


Fig. 8.

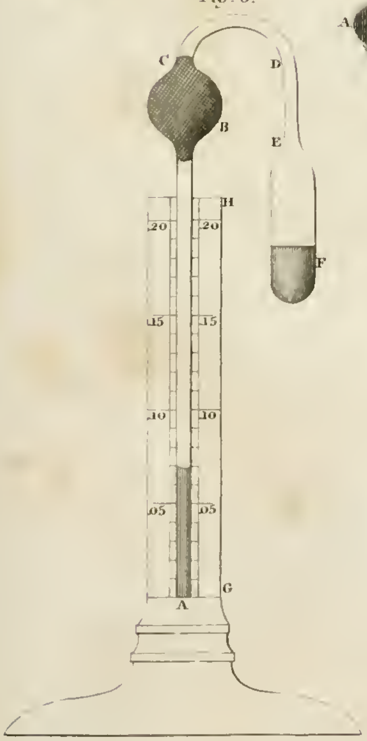


Fig. 7.

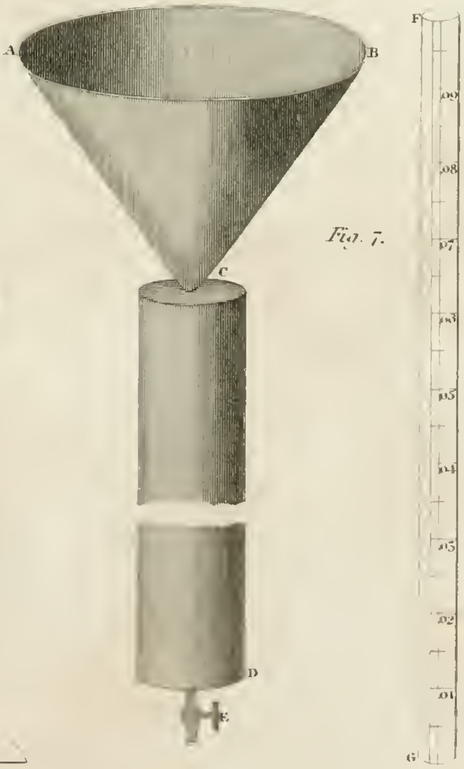
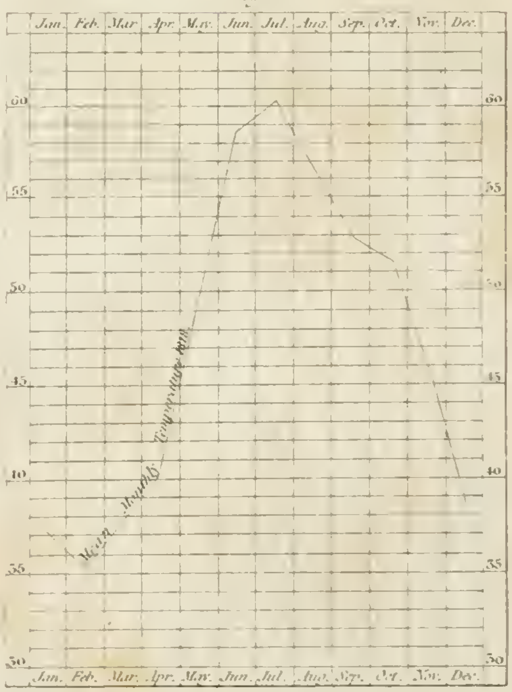


Fig. 10.



MICROMETER.

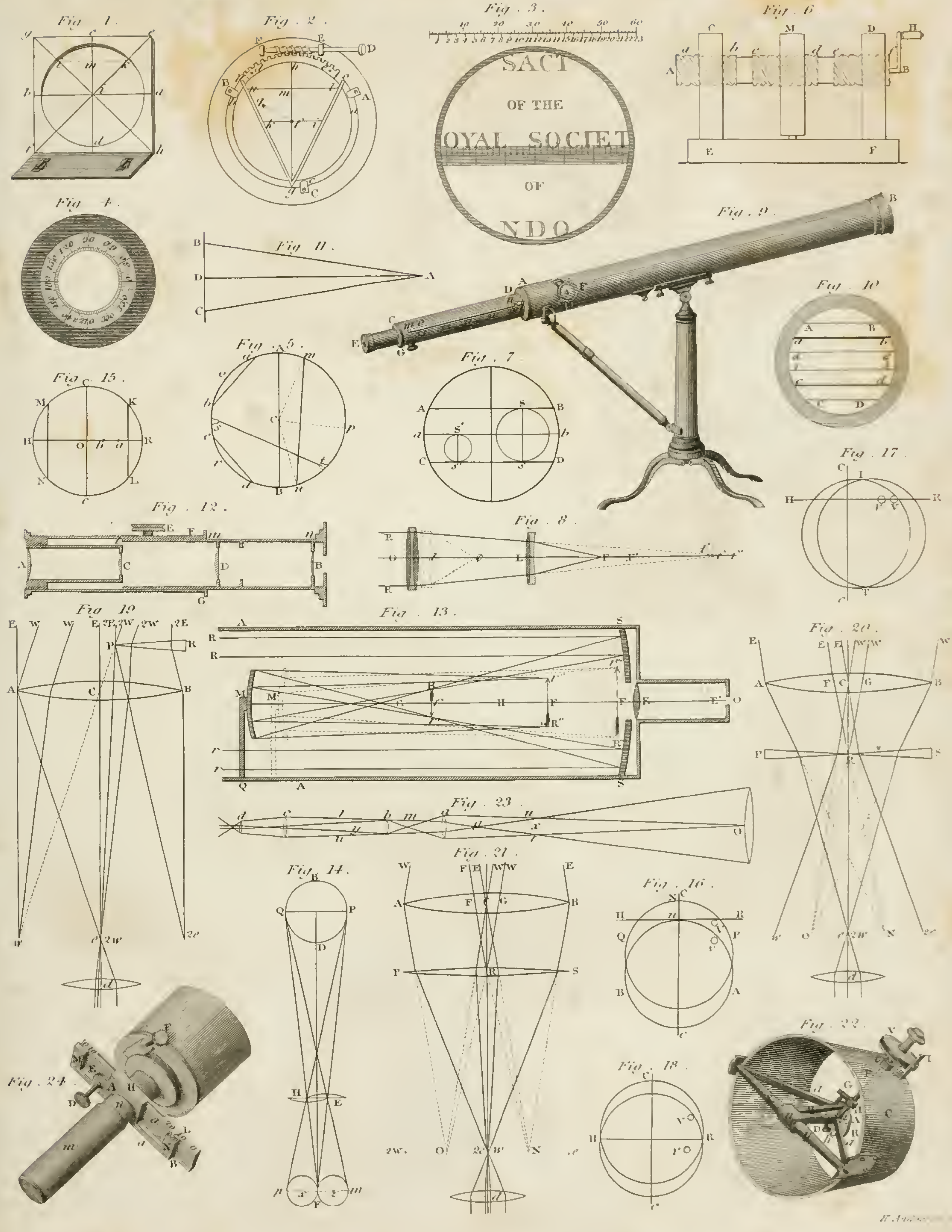


Fig. 1.
Fig. 2.
Fig. 3.
10 20 30 40 50 60
SACT
OF THE
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OF
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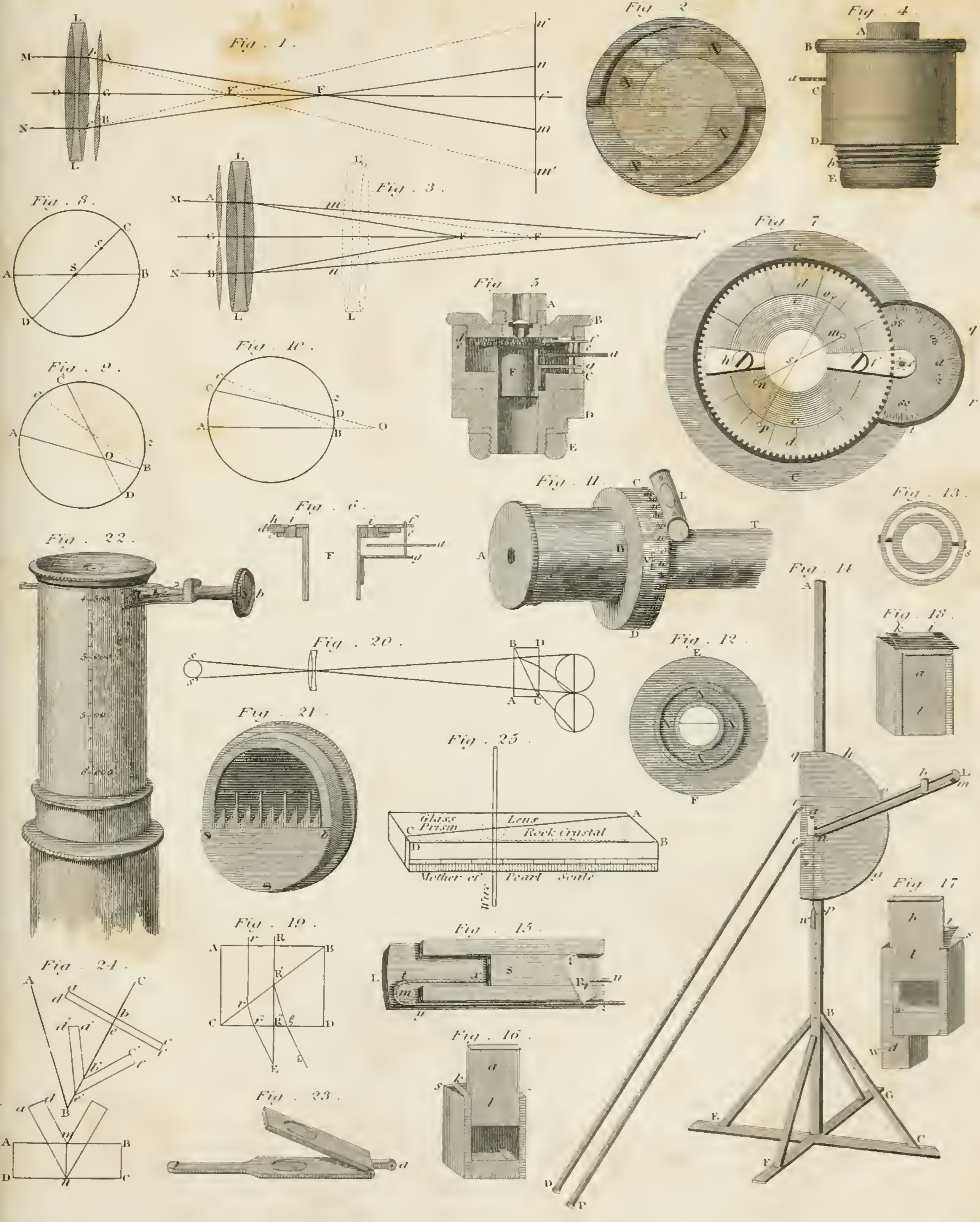
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Fig. 12.
Fig. 13.
Fig. 14.
Fig. 15.
Fig. 16.
Fig. 17.
Fig. 18.
Fig. 19.
Fig. 20.
Fig. 21.
Fig. 22.
Fig. 23.
Fig. 24.

MICROMETER. *PLATE CCCLXXVI.*



H. Anderson Sculp.t

MICROSCOPE. *PLATE CCCLXXVII.*

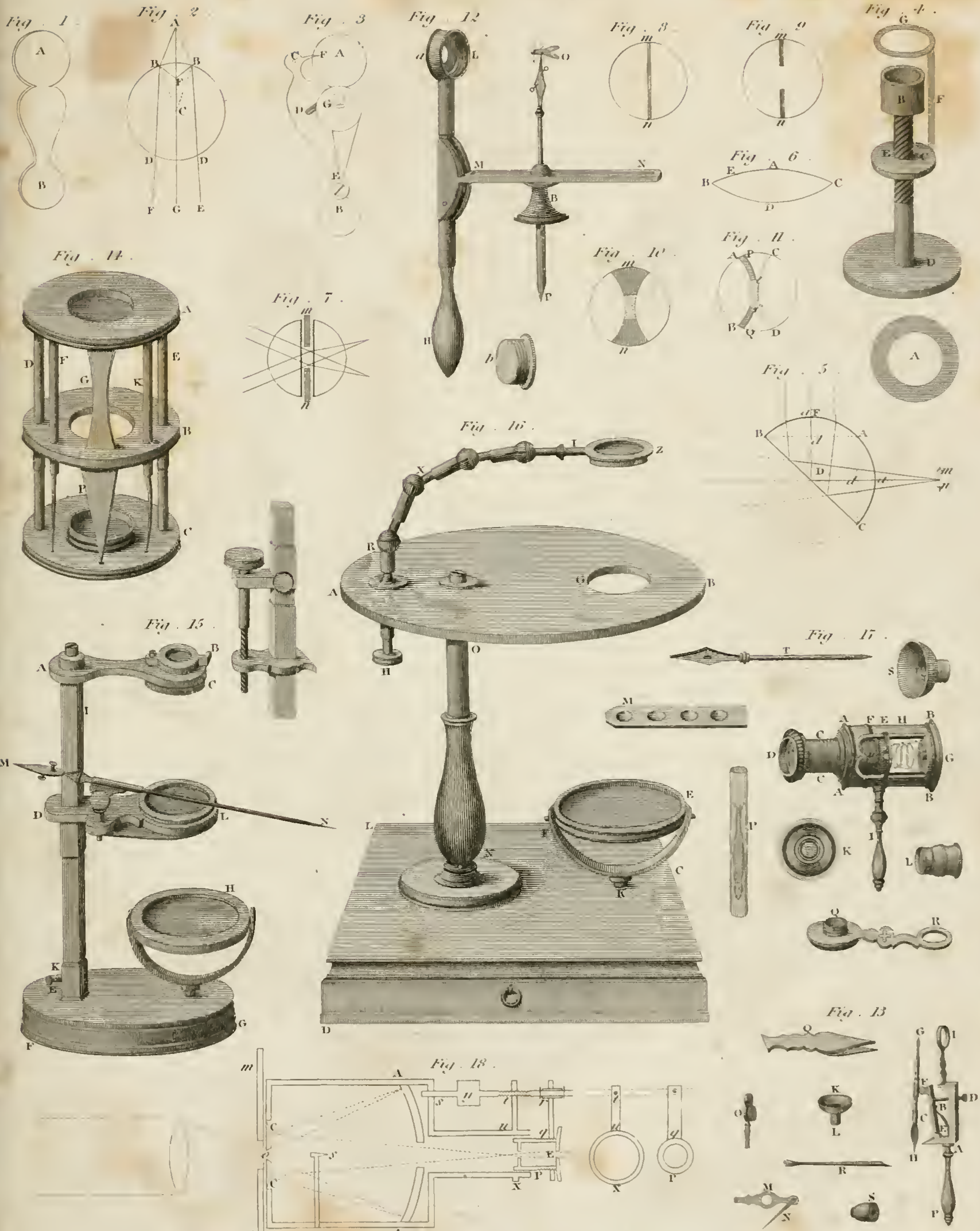
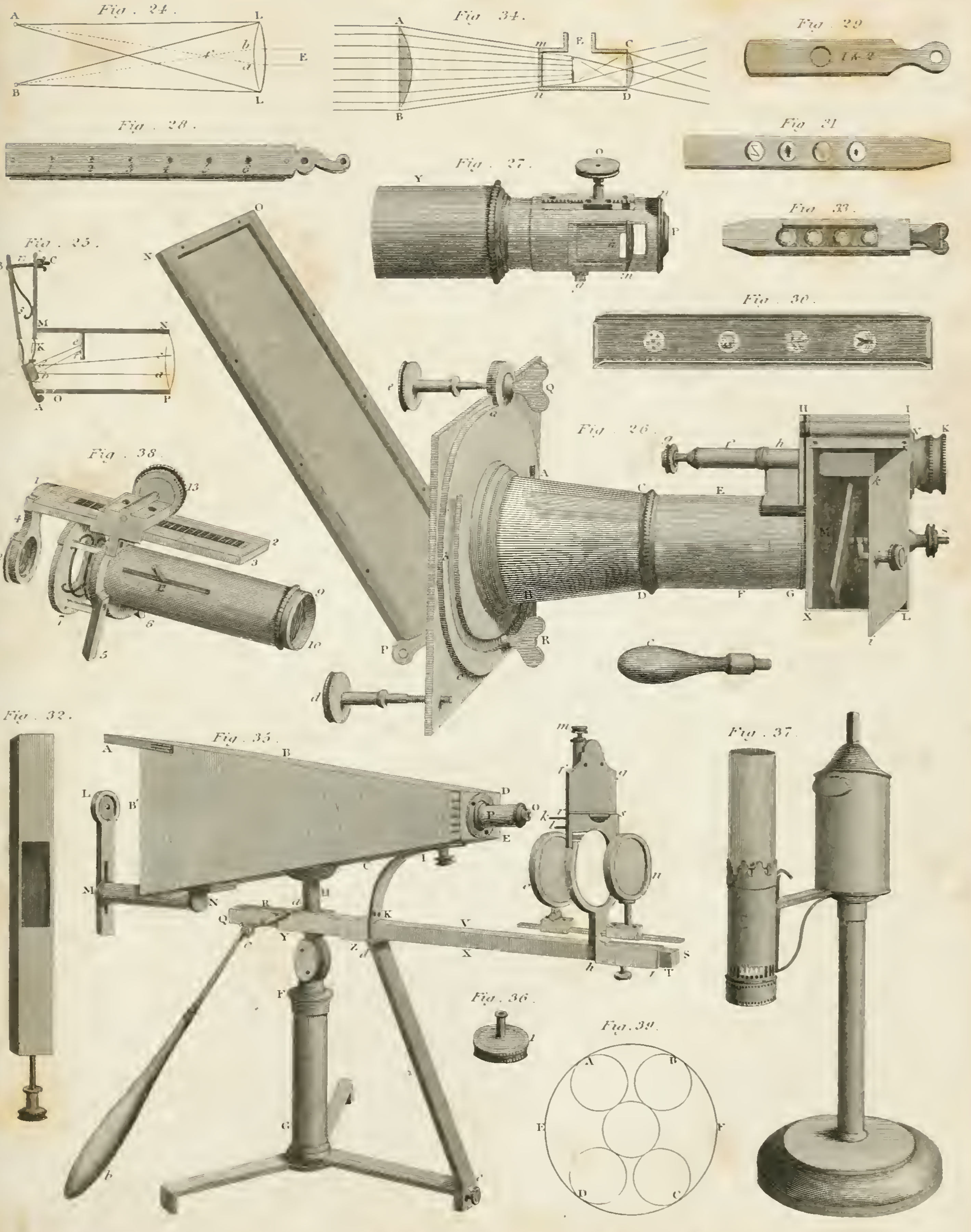


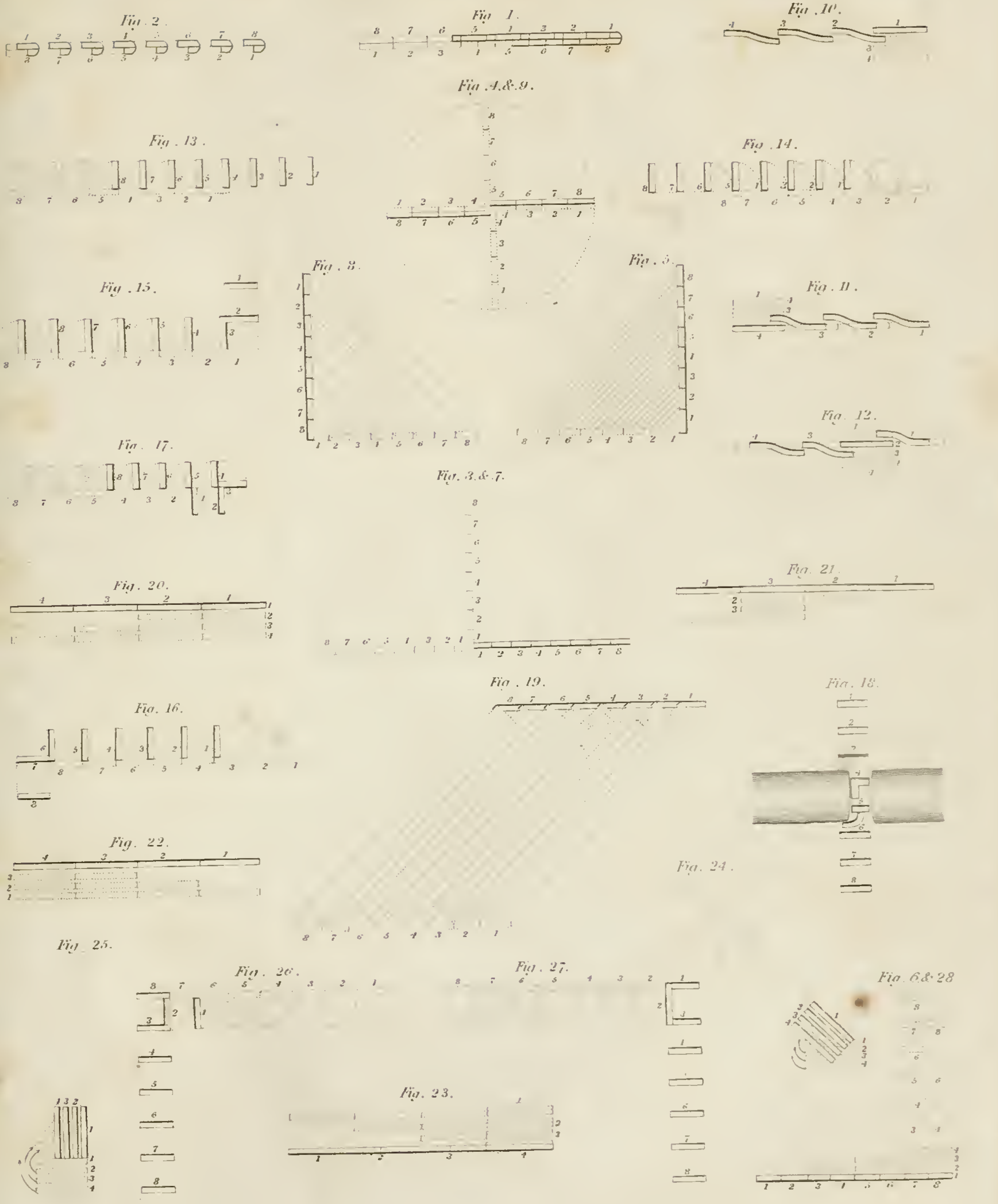

Fig. 21
Fig. 22.
Fig. 23. Nº 2
Fig. 19.
Fig. 23. Nº 3.
Fig. 23. Nº 1
Fig. 20

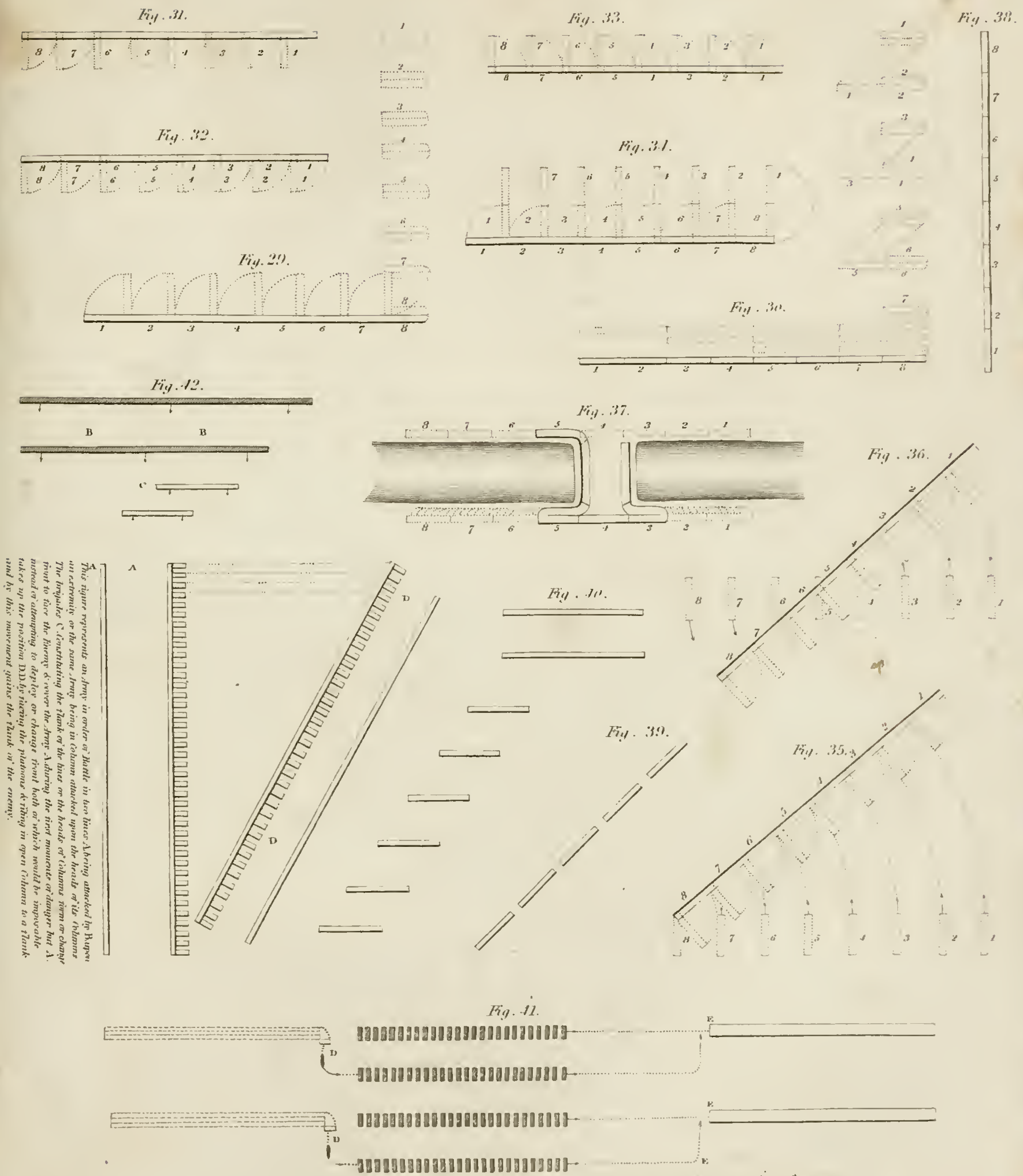
MICROSCOPE. PLATE CCCLXXXIV.



MILITARY TACTICS.

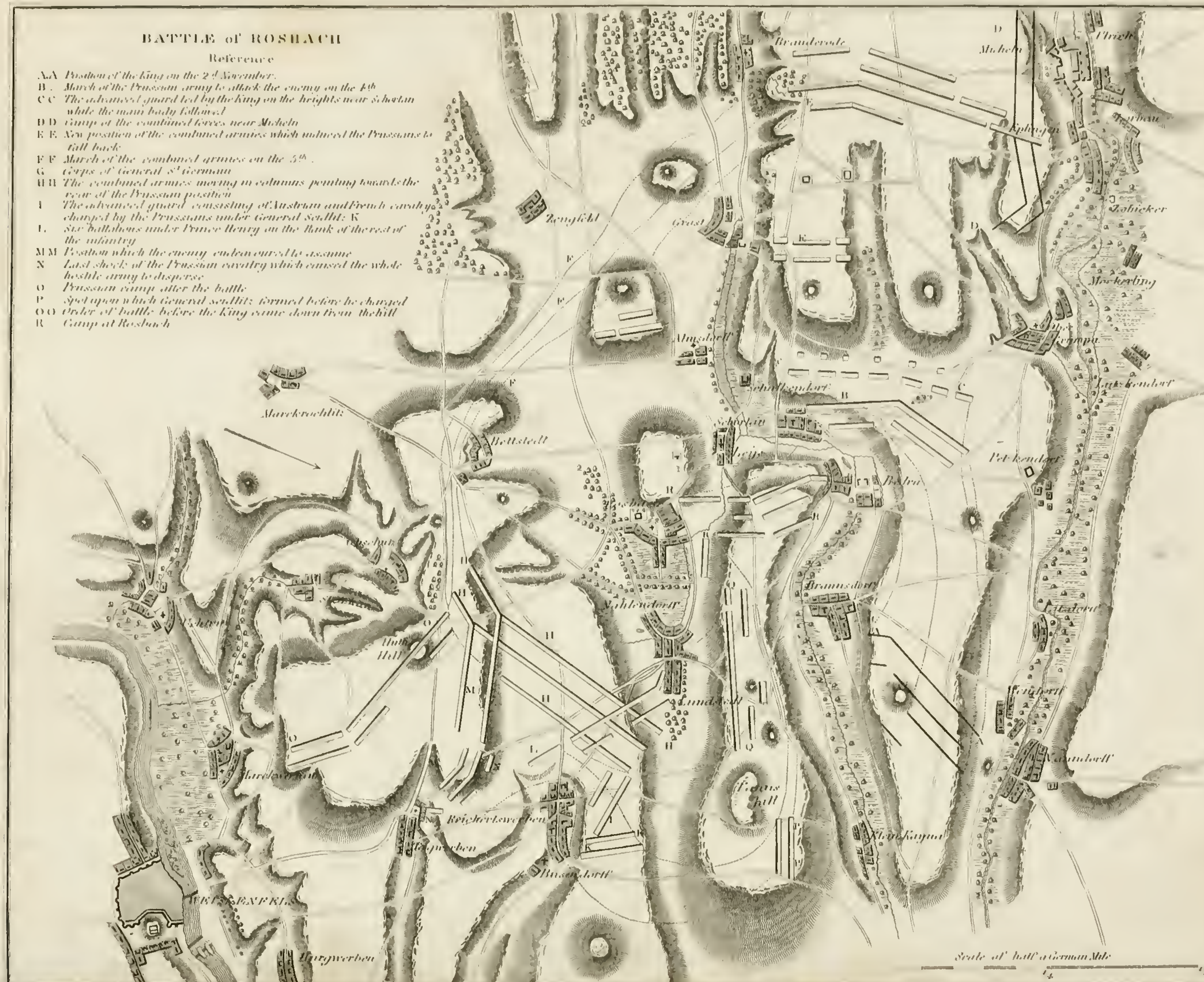
PLATE CCCLXXXI & CCCLXXXII.





Represents an Army marching by lines, doubling the columns in D so as to be in four. the four heads being arrived at E, the 2d and 4th Constituting the left wing halt and allow the others to proceed untill their rear have cleared them when they fall in the line of march & proceed again in two.

Engraved by W Hay.



Engraved by W. Hay.

MILITARY TACTICS. PLATE CCCLXXXVI.

Reference.

- A.A. Austrian grand army in order of battle.
- B. Flank or potence formed by the corps under Nadasti
- C. Advanced corps of Cavalry surprised by the Prussians and driven upon the main body in E.
- D. March of the king in four columns.
- E.F. Point where the four columns formed into two and thence moved in order of battle by the right.
- G. Prussian advanced guard.
- H.I.K. First attacks of the advanced guard sustained by the whole army the enemy giving way H. continued to move forward in column by its left projecting beyond the front of I. by which means it presented a potence the head of which turned the flank and rear of the enemy.
- L.L. The whole line having advanced gradually brought into action
- M. The left wing of the enemy thrown back into the new disposition
- N. General Driesen charging the Austrian cavalry. O.
- P. Right wing of the enemy brought into the new disposition.
- Q. Prussian cavalry of the left wing charging the enemy in flank.
- R. Last position of the Austrians.
- S.S. Again attacked by the whole army of the Prussians.
- T.T. Retreat across the Weistritz by the bridges at Rathen and Lissa and by the pontoon bridges .V.
- V.V. Prussian camp after the battle.

ORDER of MARCH and MANŒUVRES at the BATTLE of KOLLIN

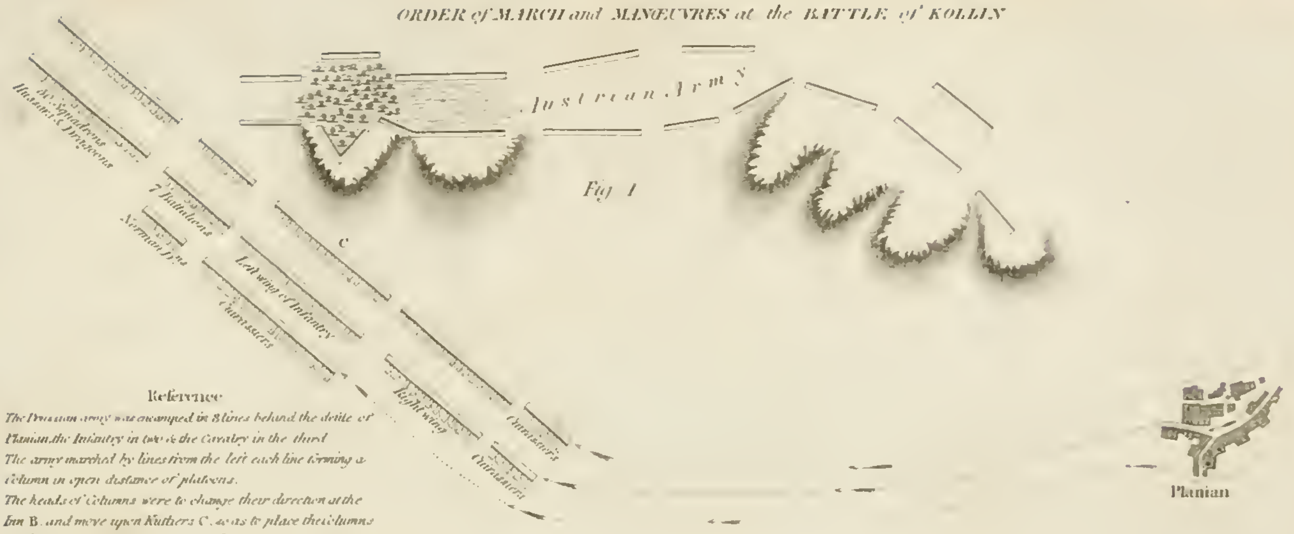


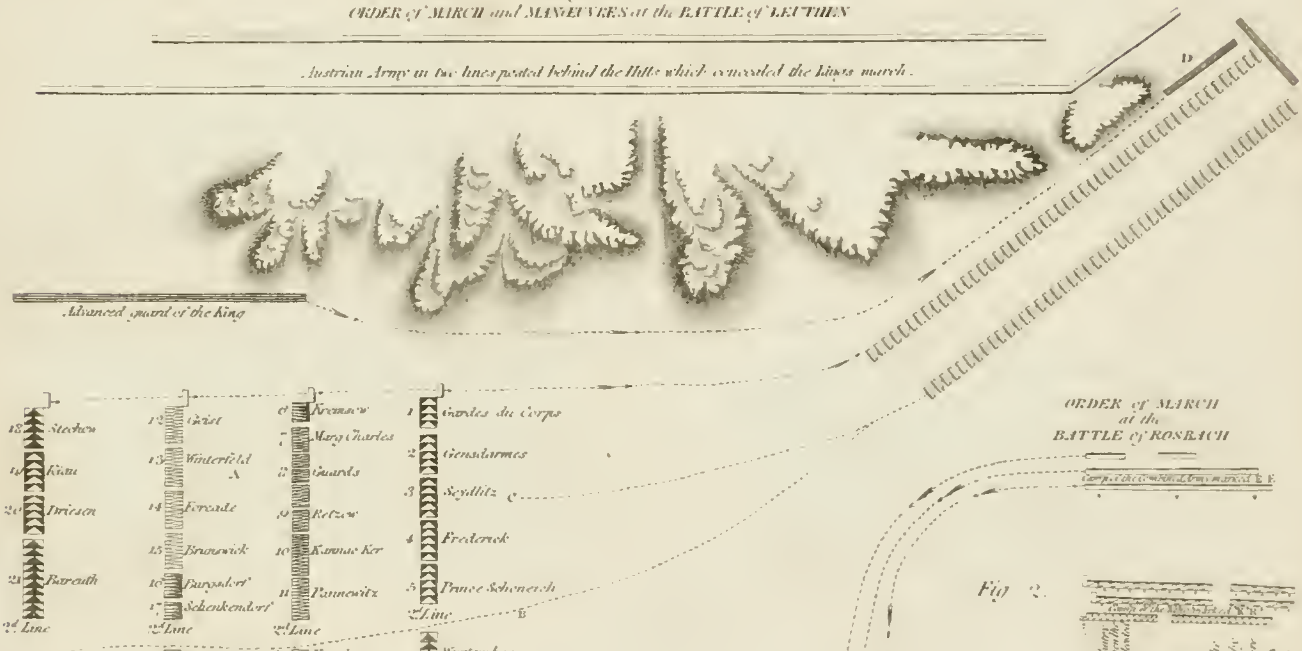
Fig. 1

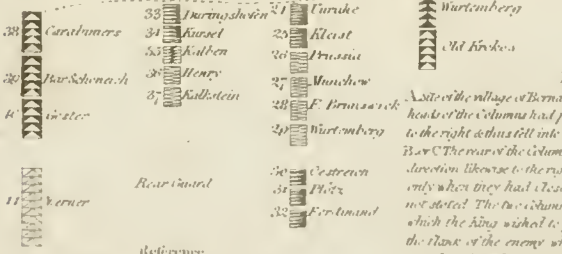
Reference

The Prussian army was encamped in 3 lines behind the defile of Planian the Infantry in two & the Cavalry in the third. The army marched by lines from the left each line forming a column in open distance of platoons. The heads of Columns were to change their direction at the Inn B. and move upon Kuthers C. so as to place the Columns on the line of the order of Battle which was to be effected by wheeling into line and not by deploying.

Fig. 3

ORDER of MARCH and MANŒUVRES at the BATTLE of LEUTHEN





Reference

Infantry	Grenadiers	Lt Infantry
Cuirassiers	Dragoons	Hussars

Reference

A site of the village of Borna between the 2d and 3d Columns when the heads of the Columns had passed it, they changed their direction to the right & thus fell into two Columns ready to wheel into line B & C The rear of the Columns constituting the 2d line changed their direction likewise to the right but whether at the same time as A or only when they had closed up to their proper distance in C. is not stated. The two Columns continued marching in the alignment which the King wished to give his Army, until they had gained the flank of the enemy when they wheeled up and the army stood in order of Battle D. Advanced guard forming an Angle or potence for the first attack B. and C. have both been dotted to denote that possibly the 2d line did not turn until it had reached the point C.

ORDER of MARCH at the BATTLE of ROSBACH

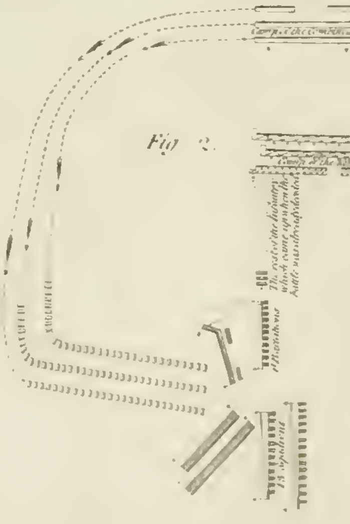


Fig. 2

Reference

The Prussian Army marched by lines from the left the Infantry in platoons and the Cavalry in sections by moving upon the intended alignment the Columns were formed in order of Battle by wheeling up without any deployment the march was concealed by the heights

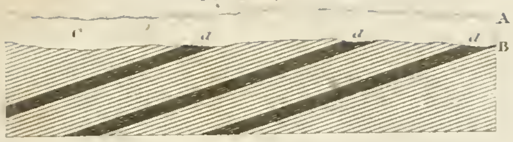


Fig. 1.

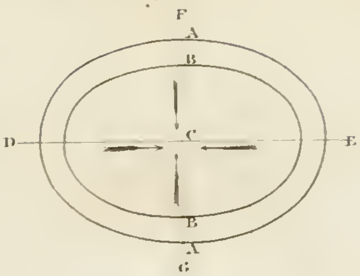


Fig. 2.

Fig. 3.

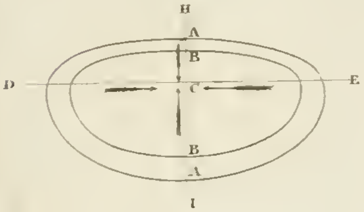
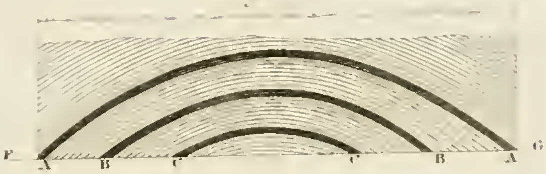


Fig. 4.



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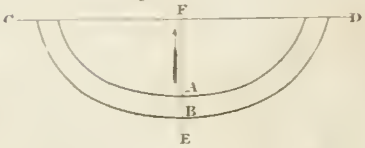
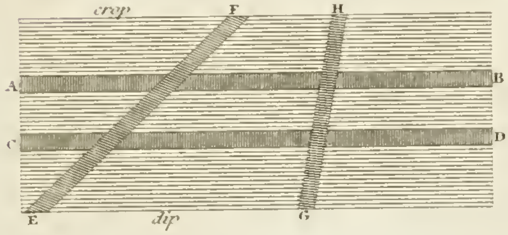


Fig. 5.



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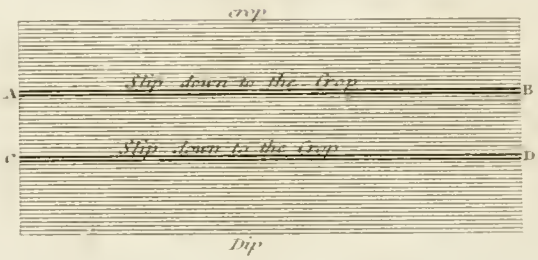

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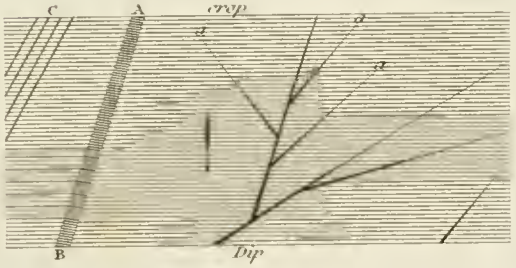


Fig. 9.

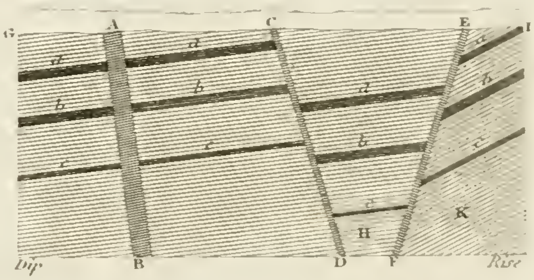


Fig. 10.

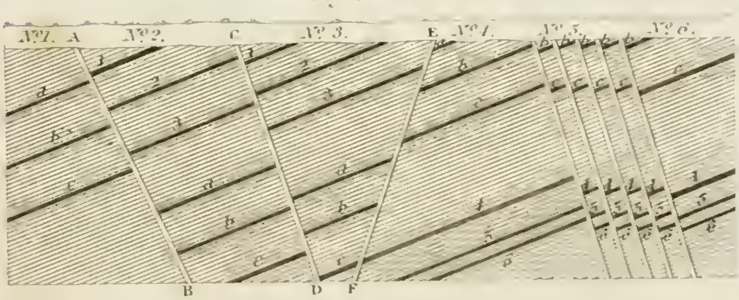


Fig. 11.

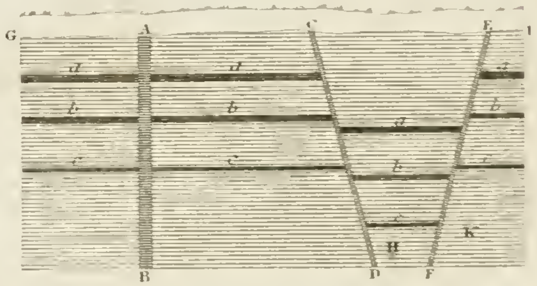


Fig. 12.

Fig. 1.

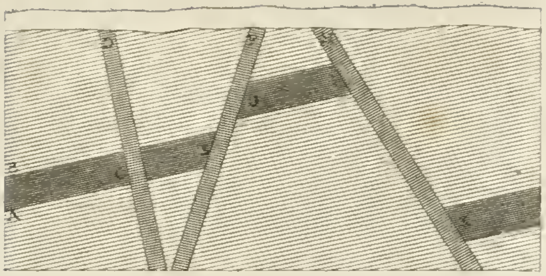
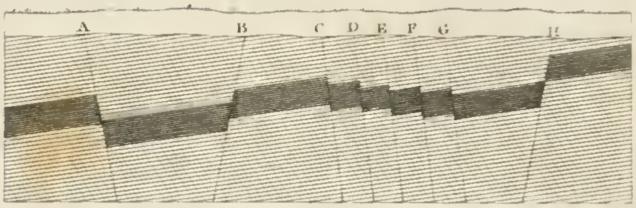


Fig. 2.



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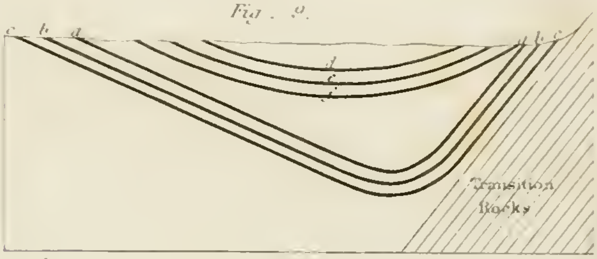

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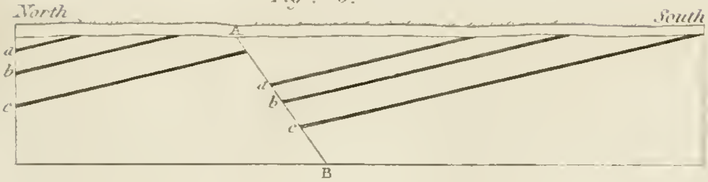

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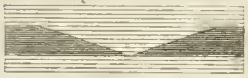
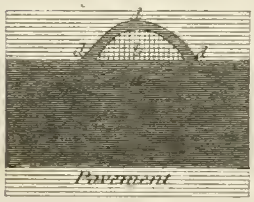


Fig. 4.

Fig. 5.



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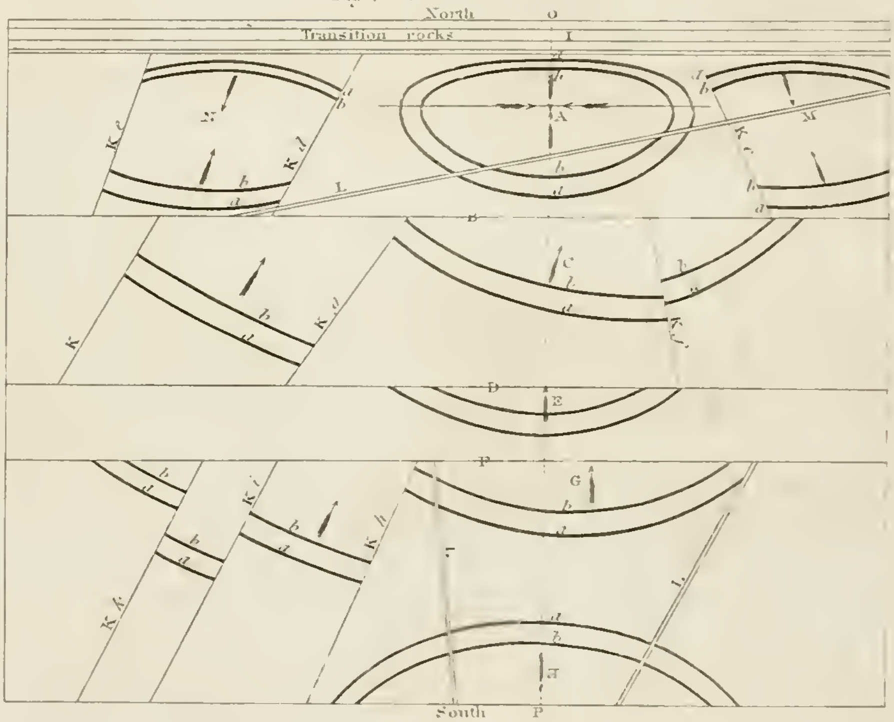

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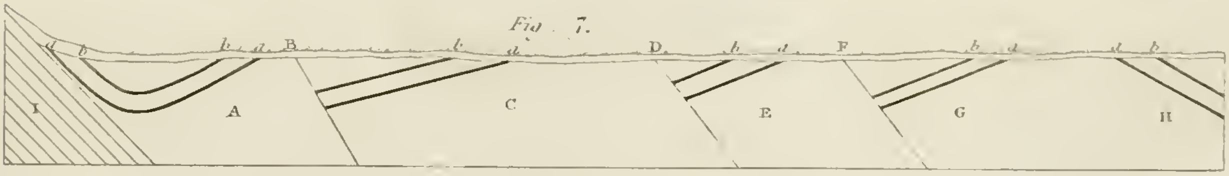

D. Haines sc.

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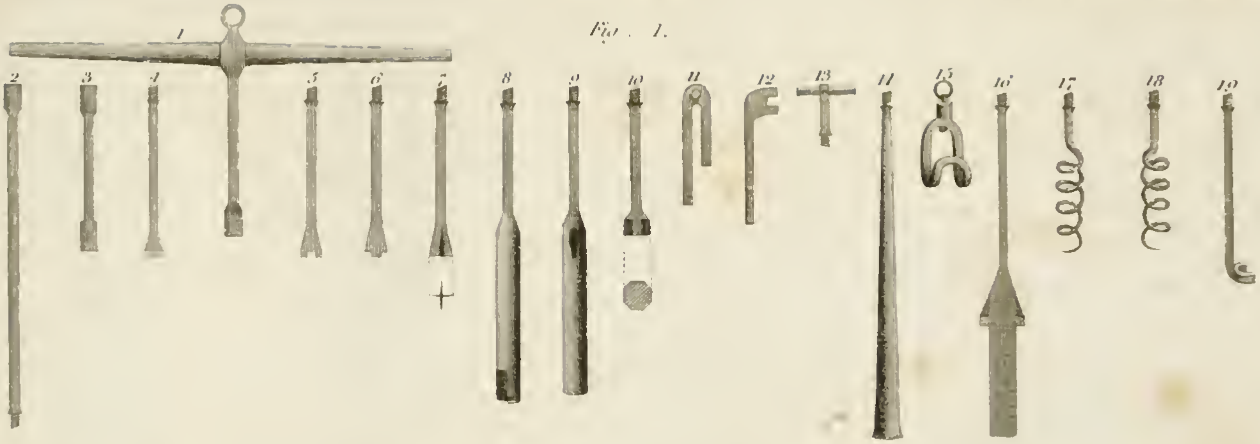

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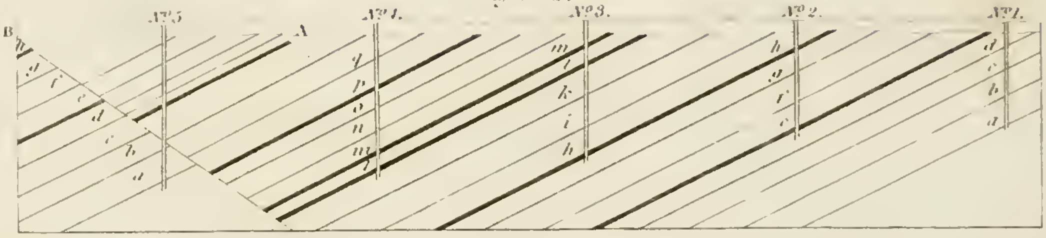

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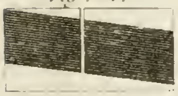

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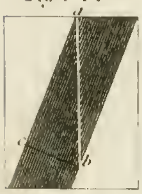

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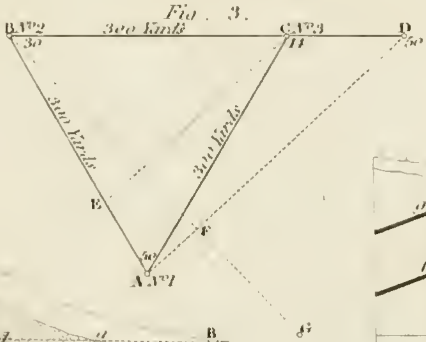

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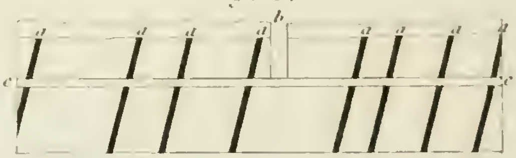

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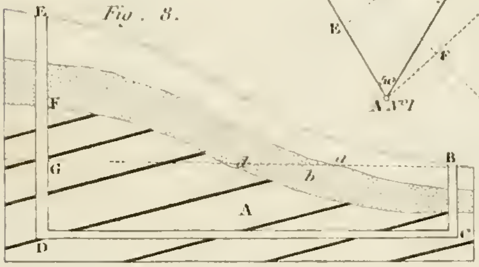

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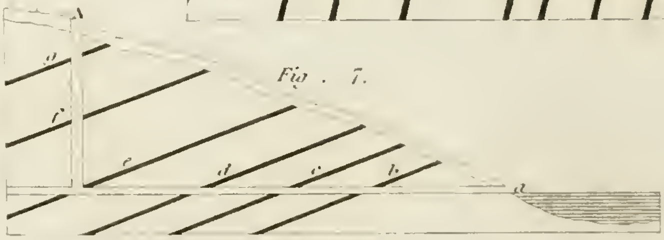

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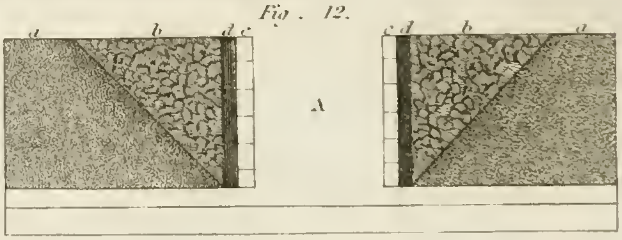

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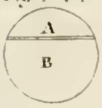

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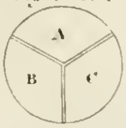

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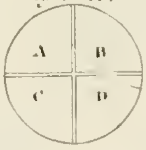


Fig. 13.

Fig. 14.

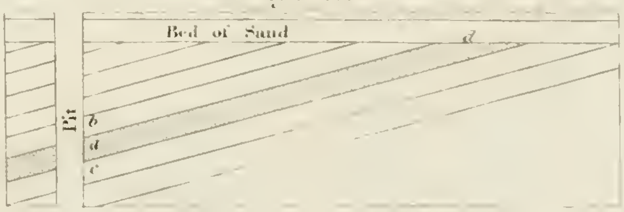
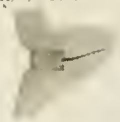


Fig. 15.

Fig. 16.



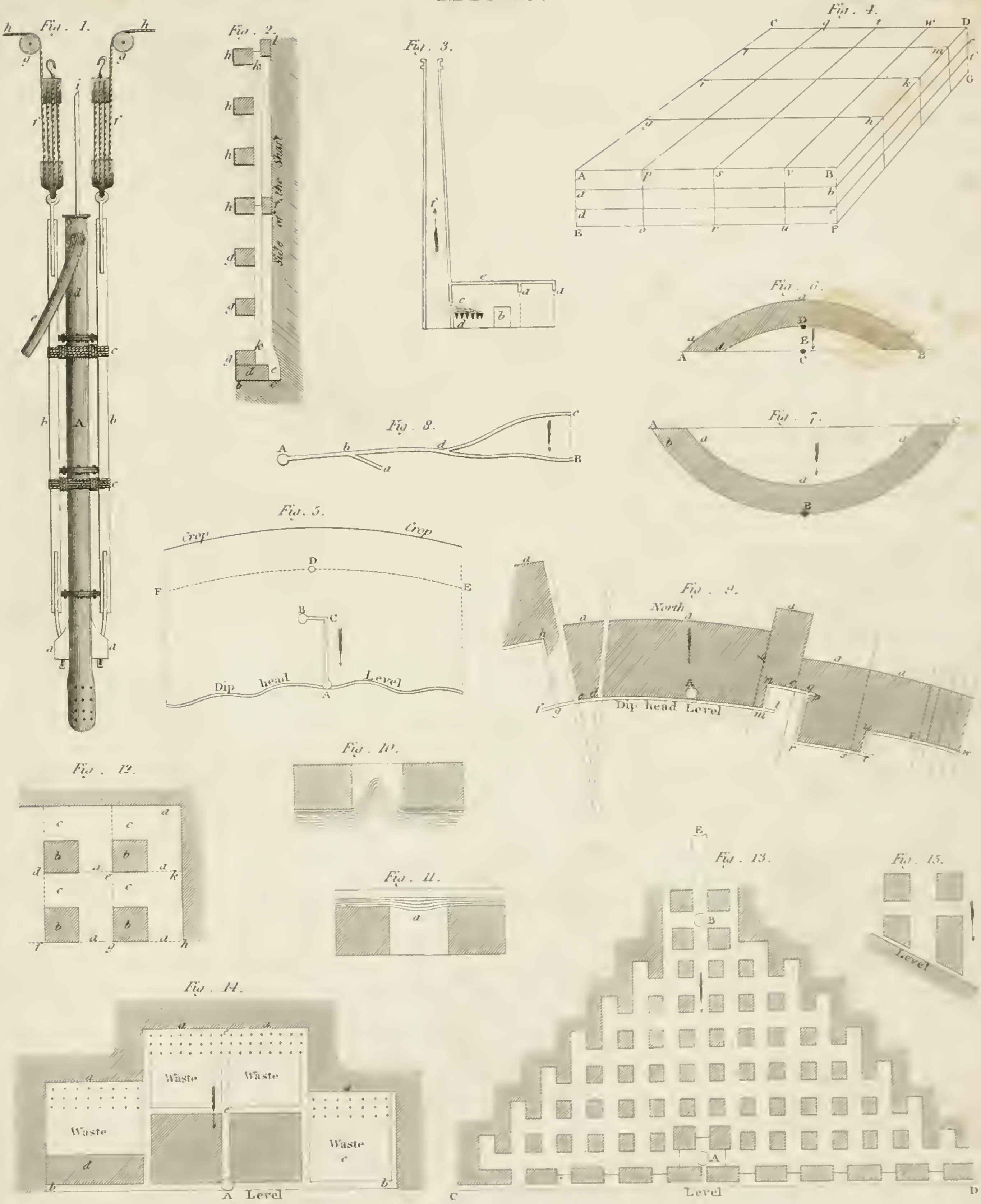


Fig. 1.
Fig. 2.
Side of the Shaft
Fig. 3.
Fig. 4.
Fig. 5.
Crop
Crop
Dip head Level
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
North
Dip head Level
Fig. 10.
Fig. 11.
Fig. 12.
Fig. 13.
Level
Fig. 14.
Waste
Waste
Waste
Waste
Waste
Level
Fig. 15.
Level

D. Hawes Sc.

MINE.

PLATE CCCXCII.

Fig. 2.

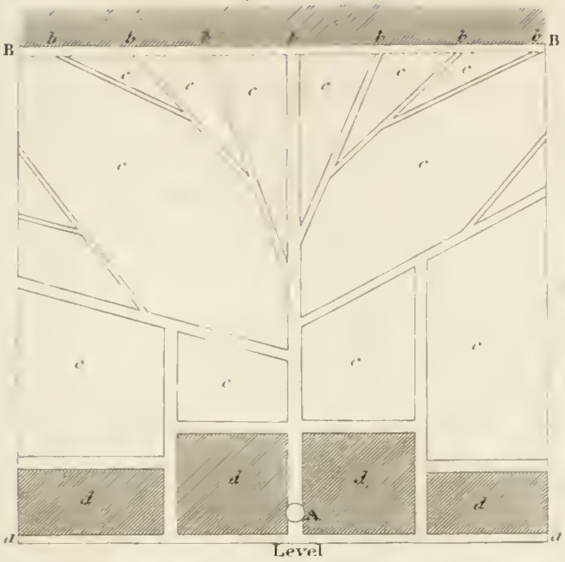
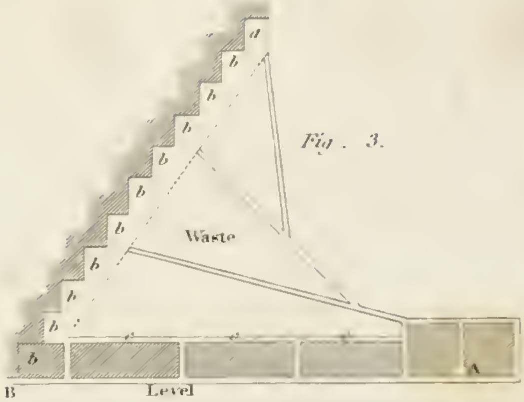


Fig. 3.



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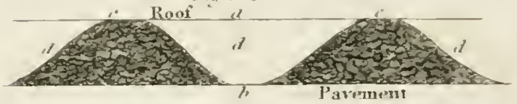

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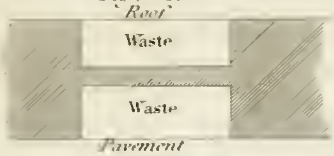

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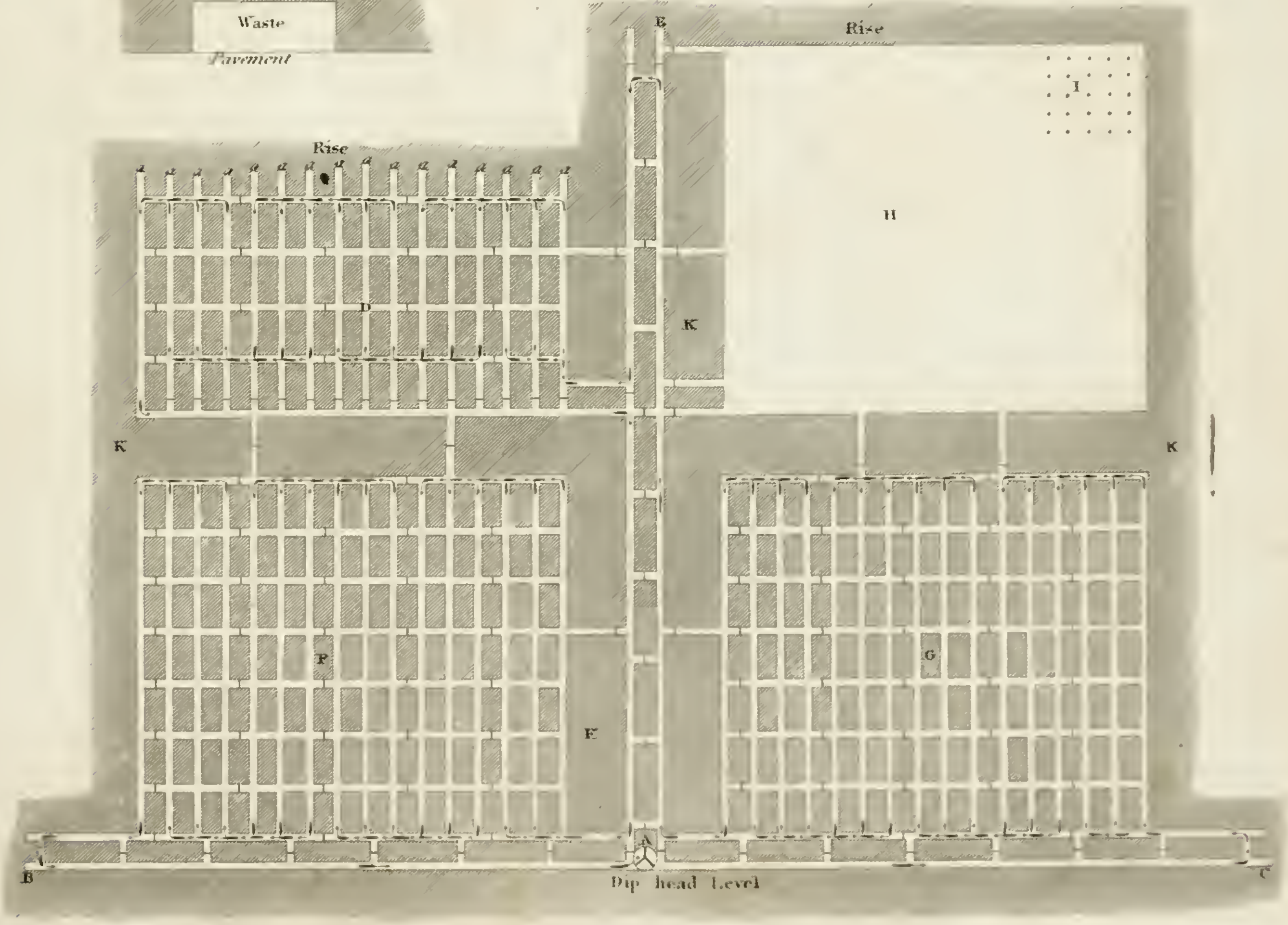
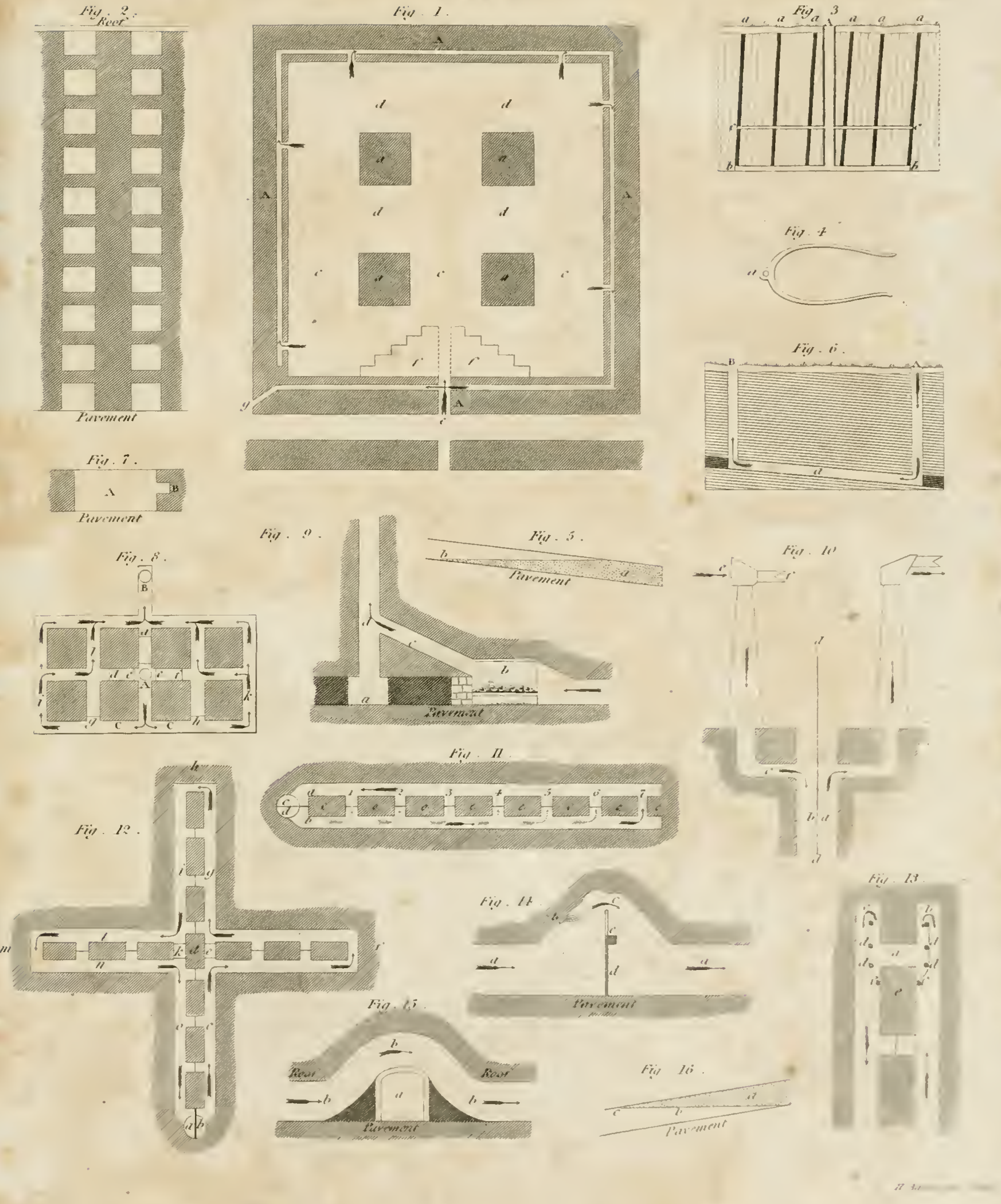


D. Haines Sc.

MINE. PLATE CCCXCIII.



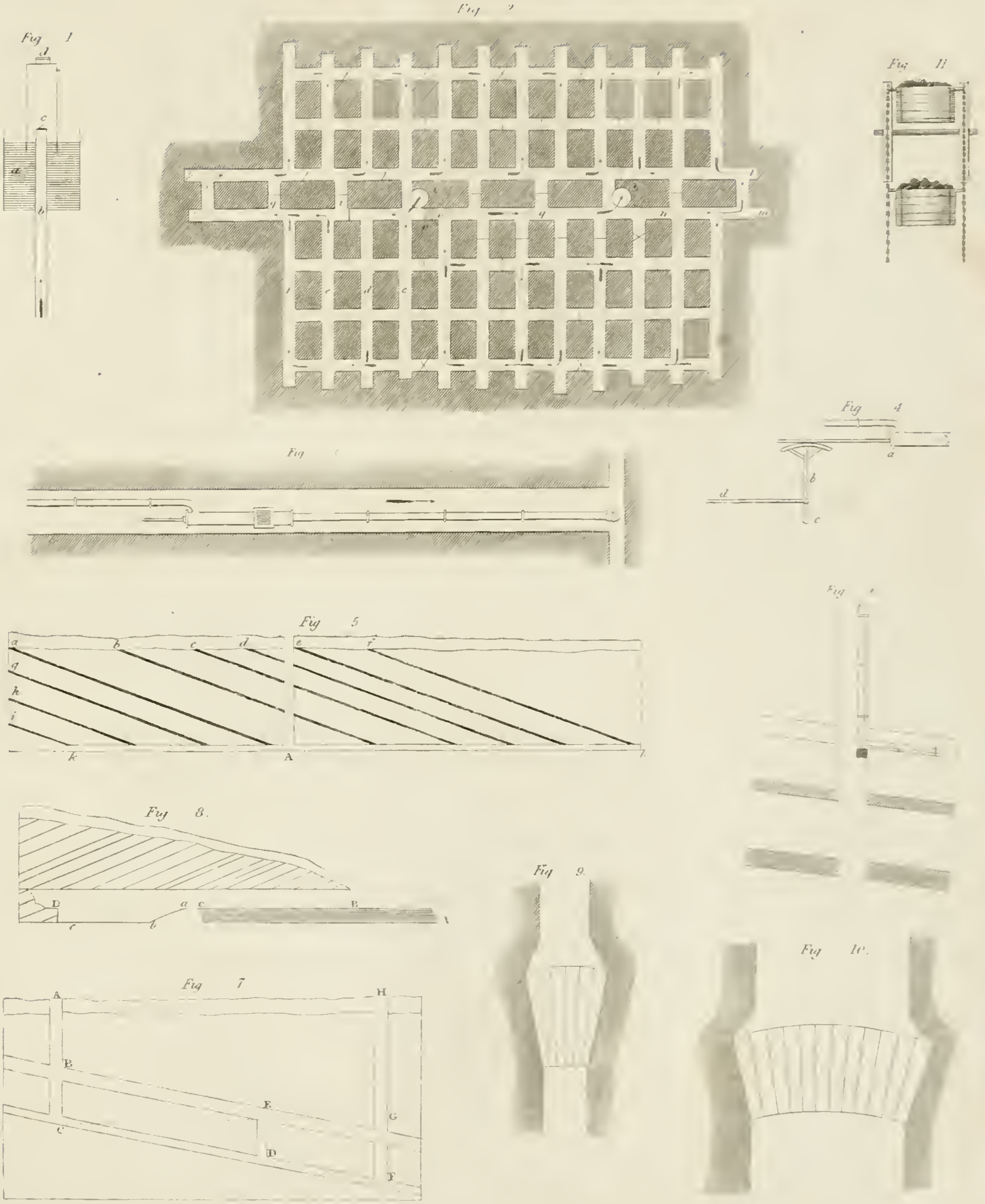
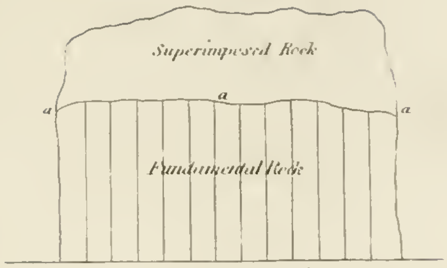


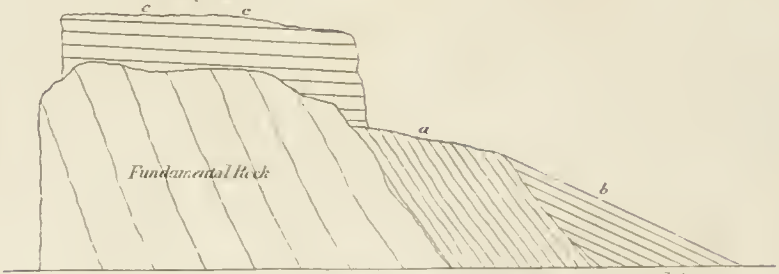
Fig 1
Fig 2
Fig 11
Fig 4
Fig 5
Fig 8.
Fig 9.
Fig 10.
Fig 7
a
b
c
d
e
f
g
h
i
k
A
B
C
D
E
F
G
H

Fig. 1.



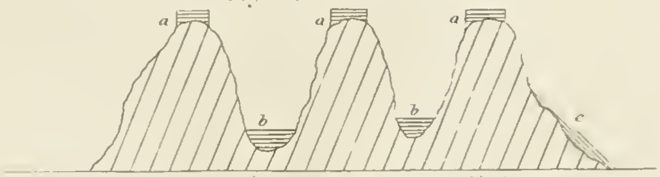
aaa. Plane of separation.

Fig. 3.



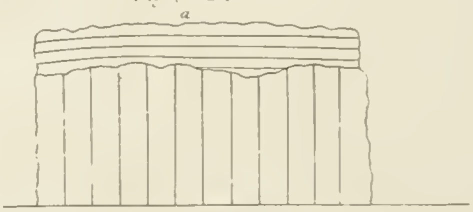
a. Conformable stratification. b. Unconformable. c c. Unconformable & overlying.

Fig. 2.



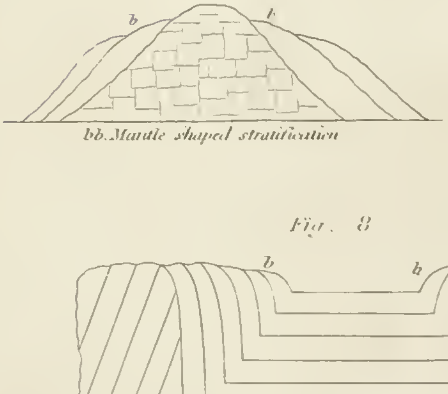
a Mountain caps. bb Upfillings. c Shield.

Fig. 4.



a. Straight stratification

Fig. 5.



bb. Mantle shaped stratification

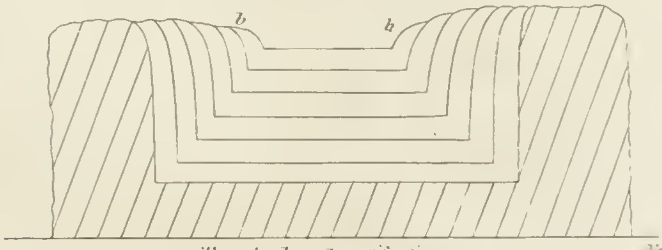
Fig. 7.

Basin shaped stratification

Fig. 6.

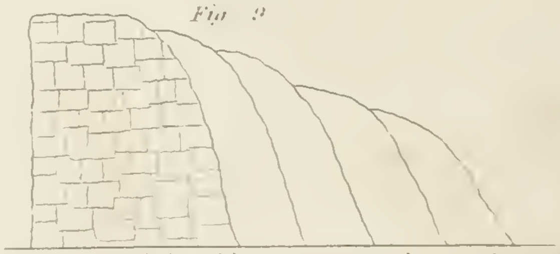
Saddle shaped stratification.

Fig. 8



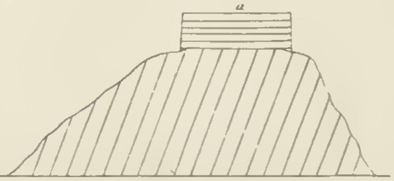
Trough shaped stratification

Fig. 9



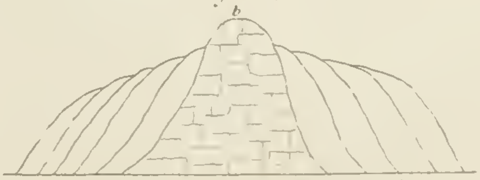
Newer strata with a sinking & rising level as we descend & ascend the mountain

Fig. 10.



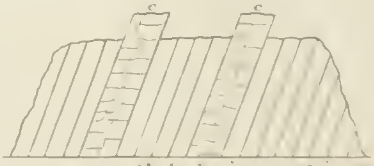
Unconformable & overlying mountain cap

Fig. 11.



b Mountain cap rising through surrounding strata.

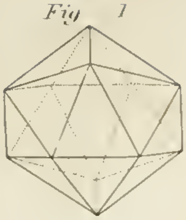
Fig. 12



c.c. Coverings or beds forming mountain caps.

MINERALOGY. PLATE CCCXCVI.

Fig. 1.



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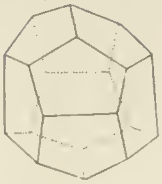


Fig. 3.

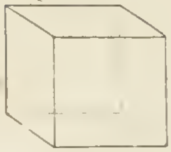


Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

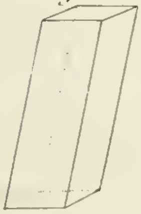


Fig. 8.

Fig. 10.

Fig. 9.

Fig. 11.

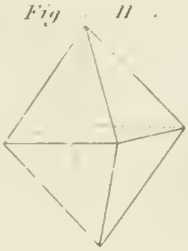
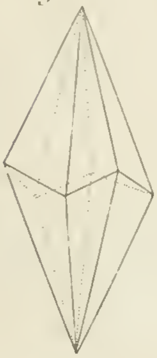


Fig. 12.

Fig. 13.

Fig. 14.



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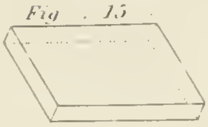


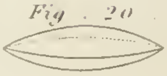
Fig. 19.

Fig. 16.

Fig. 17.

Fig. 18.

Fig. 20.



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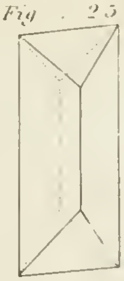


Fig. 21.

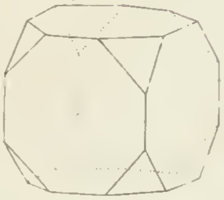


Fig. 22.

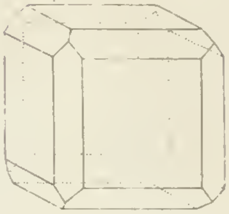


Fig. 23.

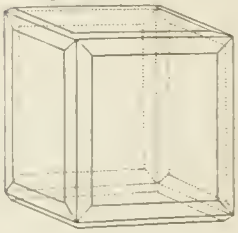


Fig. 26.

Fig. 30.

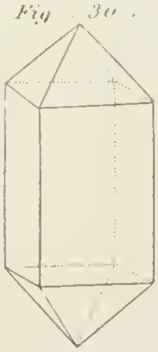


Fig. 24.

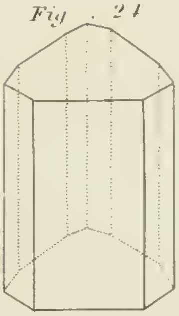


Fig. 27.

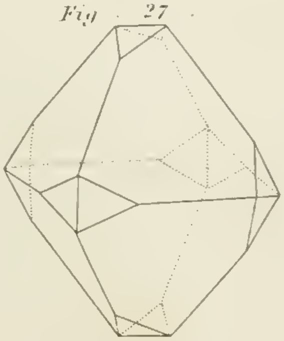


Fig. 28.

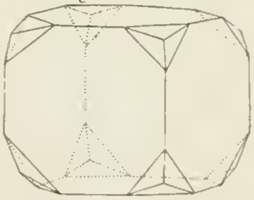


Fig. 29.

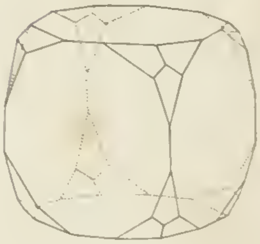


Fig. 31.

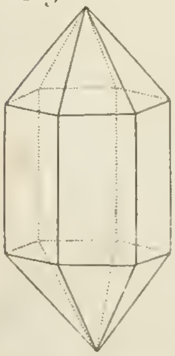


Fig. 32.

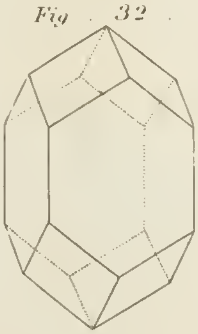


Fig. 33.

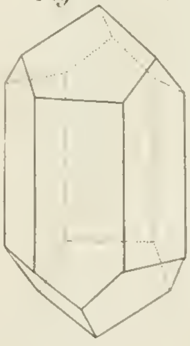


Fig. 34.

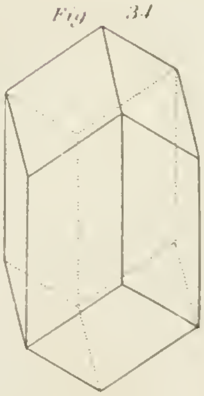
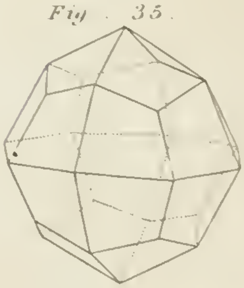


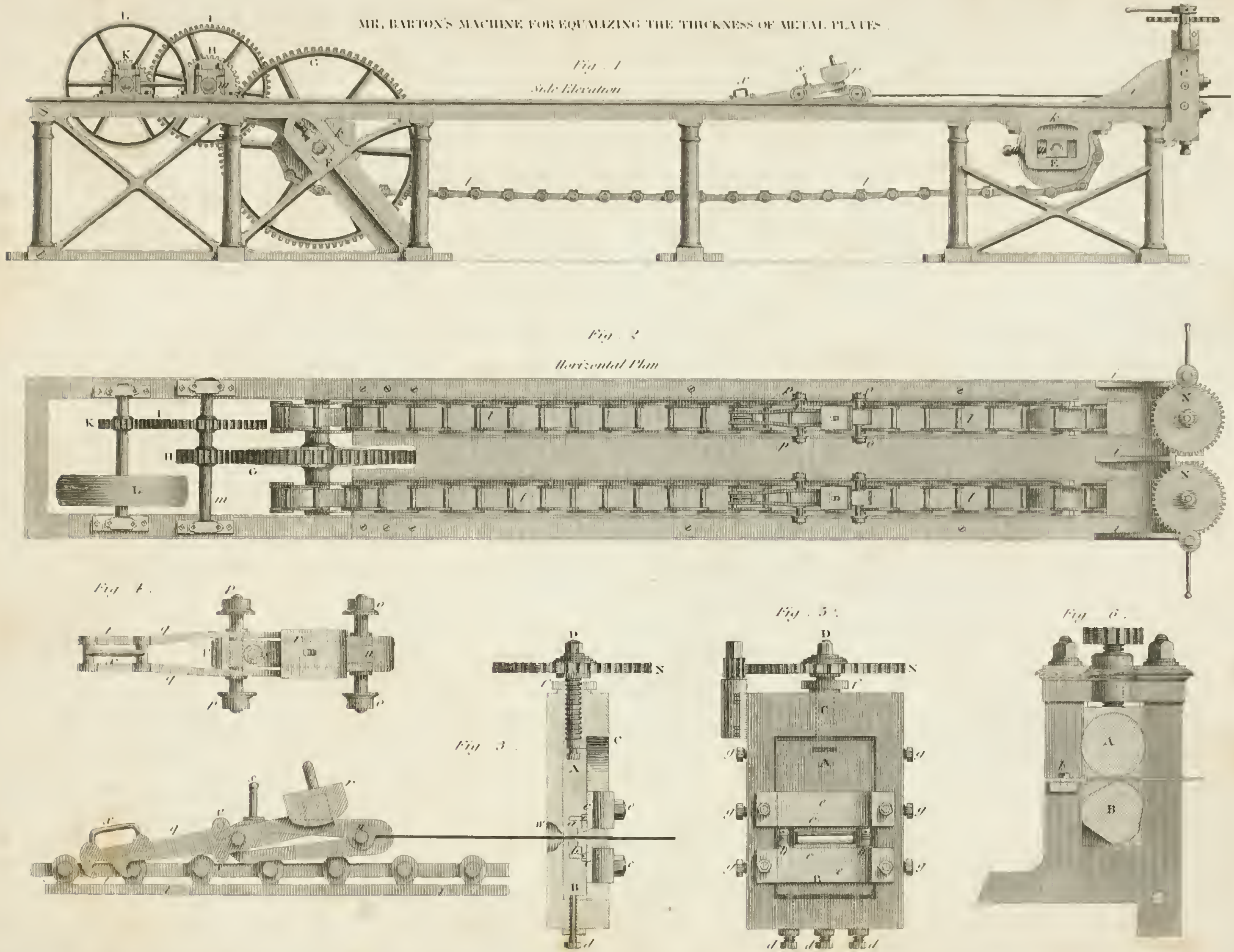
Fig. 35.



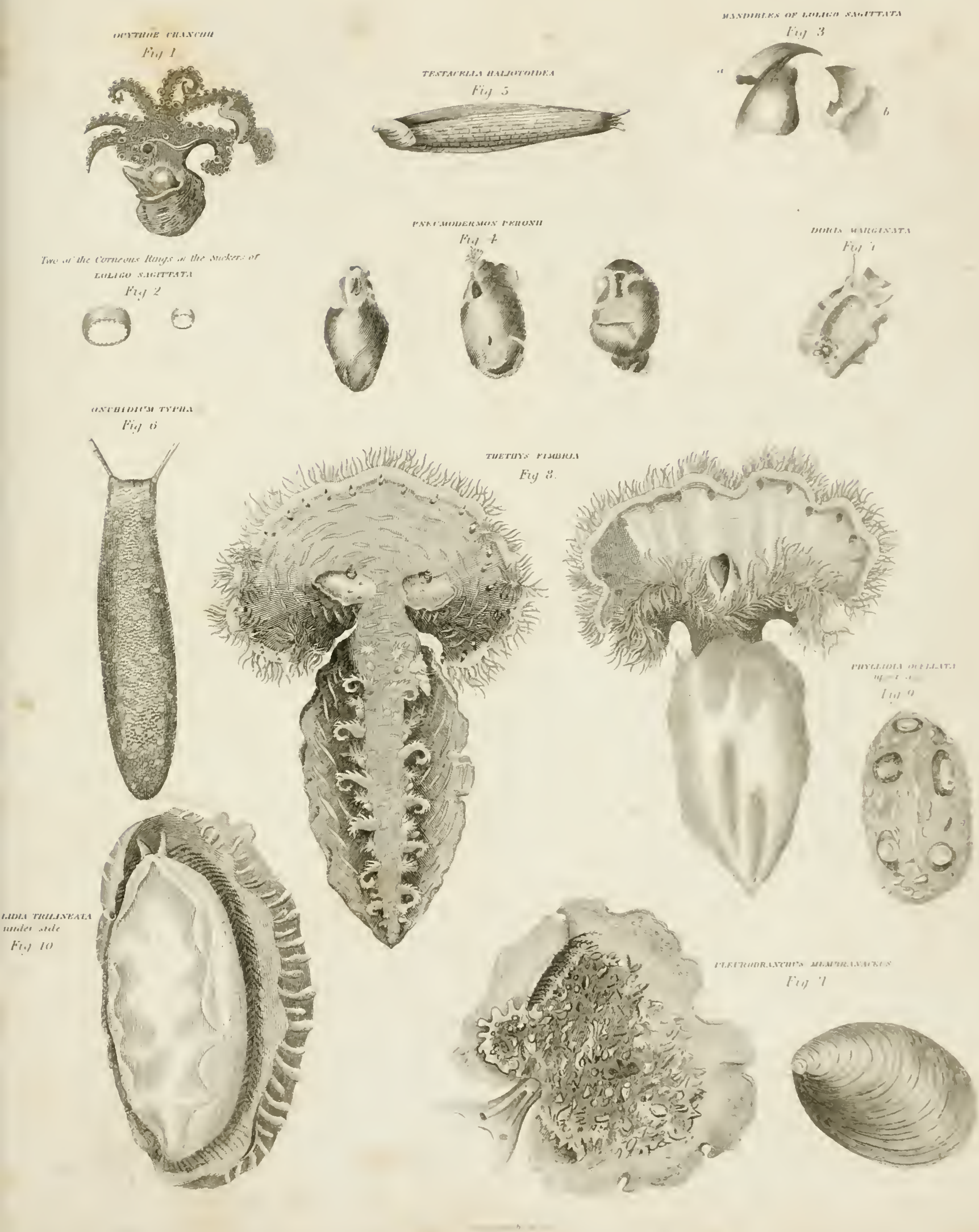
MINT.

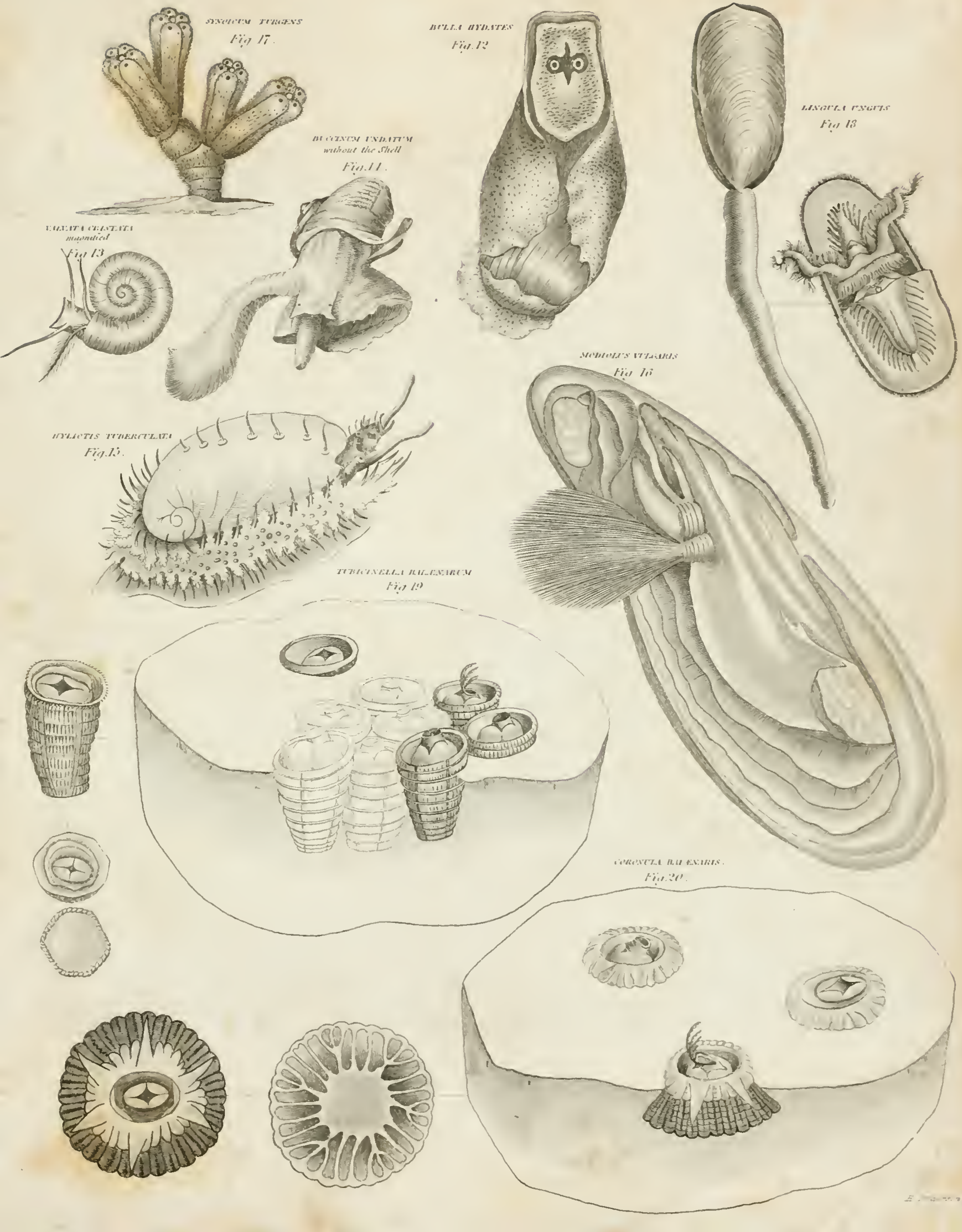
PLATE CCCXCVII.

MR. BARTON'S MACHINE FOR EQUALIZING THE THICKNESS OF METAL PLATES.



MOLLUSCA. PLATE CCCXCVIII.




SYNOICUM TURGENS
Fig 17.
BULLA HYDATES
Fig.12
LINGULA UNGUIS
Fig 18
BUCCINUM UNDATUM
without the Shell
Fig.11.
VALVATA CRISTATA
magnified
Fig 13
MODIOLUS VULGARIS
Fig 16
HYLACTIS TUBERCULATA
Fig.15.
TUBICINELLA BALÆNARUM
Fig 19
CORONULA BALÆNARIS.
Fig.20.