of 1680 within a sixth of its diameter, or as near as 147,000 miles, its tail being of a like length.

There is one comet, however, that we seem to be somewhat better acquainted with than with this that paid us so near a visit, or indeed than with any other, from its having approached us visibly for four times in succession, if not oftener. It was towards the beginning of last century that Mr. Halley was struck with the remark, that the general elements and character of the comets observed in 1531, 1607, and 1682, were nearly the same; whence he concluded that the whole formed but one identical body, that took about seventy-six years to complete its eccentric orbit; and hence, although in consequence of this eccentricity, and its travelling amid a range of heavenly bodies that are altogether invisible to us, and whose influence seems to bid defiance to calculation, it is difficult to form an estimate of its progress, he ventured to suggest, that it would appear again, making due allowances for these incidents, towards the close of 1758, or the commencement of 1759: and he had the high satisfaction of seeing his prediction verified; the comet passing its perihelion March 12th, 1759, within the limits of the errors of which he thought his results susceptible. It is apparently this comet, which, at this last period only excited the curiosity of astronomers and mathematicians, that in 1456, or four revolutions earlier, towards the close of what are called the dark ages, spread such consternation over all Europe, already, indeed, terrified by the rapid successes of the Turkish arms, that Pope Callixtus was induced to compose a prayer for the whole western church, in which both the Turks and the comet were included in one sweeping anathema.

Admitting the truth of Dr. Herschel's hypothesis, as we are now contemplating it, it is possible that some of the lately discovered planets, which are now attendant upon the sun, were formerly comets, whose orbits have for ages been growing progressively more regular, as well as their constitutional rudiments more dense; and such, indeed, is the opinion of M. Voigt, and of various other philosophers on the continent.

The object of the present and the preceding lecture has been to submit a sketch of the most obvious properties belonging to MATTER, so as to enable you to obtain a bird's-eye view of the general phenomena it is capable of assuming, and the general changes it is necessarily sustaining. From the qualities I have placed before you, of passivity, cohesibility, divisibility, and attractions of various kinds, must necessarily result, according to the intensity with which they are called into action, the phenomena of liquidity, viscidity, toughness, elasticity, symmetry of arrangement, solidity, strength, and resilience. But the powers which thus perpetually build up the inorganic world, and to this our survey has been entirely confined, perpetually also destroy it: for the whole, as I have had occasion to observe, is a continued circle of action; a circle most wise, most harmonious, most benevolent: and hence as one compound substance decays, another springs up in its place, and can only spring up in consequence of such decay.

There is, however, another lesson, if I mistake not, which we may readily learn from these lectures, however imperfectly delivered, and which is altogether of a moral character: I mean that of humility, in regard to our own opinions and attainments; and of complacency, in regard to those of others. After a revolution of six thousand years, during the whole of which period of time the restless ingenuity of man has been incessantly hunting in pursuit of knowledge, what is there in physical philosophy that is thoroughly and perfectly known even at the present moment? and of the little that is thus known, what is there which has been acquired without the clash of controversy and the warfare of opposing speculations? Truth, indeed,—for ever praised be the great Source of Truth, for so eternal and immutable a decree—has at all times issued, and at all times will issue, from the conflict; but while we behold philosophers of the highest reputation, philosophers equally balanced in the endowment of native genius, proved by the great teacher Time to have been alternately mistaken upon points to which they had hon

estly directed the whole acumen of their intellect, how absurd, how contemptible is the fond confidence of common life! Yet what, indeed, when fairly estimated by the survey that has now been briefly taken of the sensible universe,—what is the aggregate opinion, or the aggregate importance of the whole human race! We call ourselves lords of the visible creation: nor ought we at any time, with affected abjection, to degrade or despise the high gift of a rational and immortal existence.—Yet, what is the visible creation? by whom peopled? and where are its entrances and outgoings? Turn wherever we will, we are equally confounded and overpowered: the little and the great are alike beyond our comprehension. If we take the microscope, it unfolds to us, as I observed in our last lecture, living beings, probably endowed with as complex and perfect a structure as the whale or the elephant, so minute that a million of millions of them do not occupy a bulk larger than a common grain of sand. If we exchange the microscope for the telescope, we behold man himself reduced to a comparative scale of almost infinitely smaller dimension, fixed to a minute planet that is scarcely perceptible throughout the vast extent of the solar system; while this system itself forms but an insensible point in the multitudinous marshallings of groups of worlds upon groups of worlds, above, below, and on every side of us, that spread through all the immensity of space, and in sublime, though silent harmony, declare the glory of God, and show forth his handy work.

LECTURE VI.

ON GEOLOGY.

THERE are some subjects on which the philosopher is obliged to exercise nearly as much imagination as the poet; for it is the only faculty by which he can expatiate upon them. Such is a great part of the magnificent study upon which we have touched in our preceding lectures. Space, immensity, infinity, pure incorporeal intelligence, matter created out of nothing, innumerable systems of worlds, and innumerable orders of beings;—where is the mind strong enough to grapple with such ideas as these? They at once entice and overwhelm us. Reason copes with them till she is exhausted, and then gives us over to conjecture. Hence, as we have already seen, invention at times takes the place of induction, and the man of wisdom has his dream as well as the man of fancy.

Let us descend from such magnificent flights: let us quit the possible for the actual; and equally incapable of following up the fugitive material of which the visible universe consists, into its elementary principles and collective mass, let us examine it as far as we are able, in the general laws, structure, and phenomena it exhibits in the solid substance of the globe on which we tread.

It is this inquiry that constitutes the science of GEOLOGY, a brief outline of which is intended as a study for the present lecture;—a science than which few are of more importance, but which is only at present in its infancy, and of course almost entirely indebted for its existence to the unwearied assiduity and discoveries of modern times.

The direct object of geology is, to unfold the solid substance of the earth—to discover by what causes its several parts have been either arranged or disorganized—and from what operations have originated the general stratification of its materials, the inequalities of its surface, and the vast variety of bodies that enter into its make.

In pursuing this investigation, many difficulties occur to us. The bare surface, or mere crust of the earth's structure, is the whole we are capable of boring into, or of acquiring a knowledge of, even by the deepest clefts of volcanoes, or the deepest bottoms of different seas. It is not often, however, that we have the power of examining either seas or volcanoes so low as to their bottom. The inhabitable part of the globe bears but a small proportion

to the uninhabitable, and the civilized an almost infinitely smaller proportion still. Hence our experience must be extremely limited; a thousand facts may be readily conceived to be unfolded that we are incapable of accounting for; and, at the same time, a variety of contradictory hypotheses to be formed with a view of accounting for them.

So far as the superficies of the earth has been laid open to us by ravines, rivers, mines, earthquakes, and other causes, we find it composed of a multitude of stony masses, sometimes simple, or consisting of a single mineral substance, as limestone, serpentine, or quartz; but more frequently compound, or constructed of two or more simple materials variously intermixed and united; as granite, which is a composition of quartz, felspar, and mica; and sienite, which is a composition of felspar and hornblend. These stony masses or rocks are numerous, and they appear to be laid one over the other, so that a rock of one kind of stone is covered by a rock of another kind, and this second by a third kind, and so on, in many instances, for a very considerable number of times in succession. In this superposition of rocks it is easily observable that their situation is not arbitrary. Every stratum occupies a determinate place; so that they follow each other in regular order from the deepest part of the earth's crust, which has been examined, to the very surface. Thus there are two things respecting rocks which claim our peculiar attention—their composition and their relative situation. And independently of the rocks thus considered as constituting almost the whole of the earth's crust, there are other masses of fossil materials that must be likewise minutely studied; which traverse rocks in a different direction, and are known by the name of veins; as if the rocks had been split asunder in different places from top to bottom, and the chasms had been afterward filled up with the matter which constitutes the vein. And hence the VEINS which intersect rocks are as much entitled to our attention as the STRUCTURE and SITUATION of the rocks themselves.

Rocks, as to their STRUCTURE, may be contemplated under two divisions, *simple* and *compound*.

The simple division is, however, rather a speculative than a practical contemplation. It is possible that rocks, and of immense magnitude, may exist in parts of the globe we are not acquainted with, that are perfectly simple and unmixed in their structure; but it is seldom, perhaps never, that they have been actually found in such a state, at least to any considerable extent.

It is only under a compound form, therefore, or as composed of more than one mineral substance, that rocks are to be contemplated in our present survey of the subject; and in this form we meet with them of two kinds: CEMENTED, or composed of grains, or nodules, agglutinated by a cement, as sandstone and breccia or pudding-stone; and AGGREGATED, or composed of parts connected without a cement, as granite and gneiss. The component parts of the cemented rocks are often very multifarious; those of granite and gneiss much less so, consisting chiefly of felspar, mica, and quartz, with garnets, shorl, or hornblend occasionally intermixed with the mass. The granite that forms the flag-stones of Westminster Bridge are supposed to have been brought from Dartmoor; and, like the rest of the Dartmoor granite, is remarkable for the length of its crystals of felspar, which in some instances are not less than four inches.

The aggregate rocks, like the cemented, are sometimes found of an indeterminate, but more generally of a determinate or regular form; and it is the office of that branch of mineralogy to which M. Werner has given the name of *oryctognosy*, to distinguish and describe them by these peculiarities. This is a branch into which I cannot plunge, for it would lead us from that general view of the science to which our present course of study is directed, into a detailed analysis. Those who are desirous of pursuing it in this line of developement may consult with great advantage Professor Jameson's System of Mineralogy, or M. Brogniart's Traité Elémentaire, or M. Cuvier's Essay on the Theory of the Earth, prefixed to his Fossil Remains. I can only observe, at present, that the total number of rocky masses, or different kinds of

rocks, whether simple or compound, which have been hitherto observed, amount to about sixty; of which the principal seem to be the eight following: granite, gneiss, hornblend, limestone, wacke, basalt, quartz, and clay.

Let us next pass on, then, to consider their RELATIVE SITUATION. Of the different rocks thus glanced at, and placed over each other, the whole crust of the earth is composed, to the greatest depth that the industry of man has been able to penetrate; and I have already observed, that with respect to each other, they occupy a determinate situation, which holds invariably in every part of the globe. Thus, limestone, excepting under particular circumstances, hereafter to be explained, is nowhere found under granite, but always above it. This general view of the subject may, indeed, induce a supposition that every separate layer which constitutes a part of the earth's surface is extended round the entire globe, and wrapped about the central nucleus, like the coats of an onion; the kind of rock that is always lowest, or nearest the centre, uniformly supporting a second kind, and this second kind a third, and so on. Now, though the different kinds or layers of rocks do not in reality extend round the earth in this uninterrupted manner—though, partly from the inequality of the nucleus on which they rest, partly from their own inequality of thickness in different places, and partly from other causes, the continuity is often interrupted—yet still we trace enough of it to convince us that the rocks which constitute the crust of the earth, when contemplated upon a large scale, are every where the same, and that they invariably occupy a like situation with respect to each other.

The labours of Mr. Kirwan and M. de Saussure gave the earliest hints upon this subject; and the geological theories of Professor Werner of Freyburg, and of M. de Cuvier of Paris, are entirely founded on the same. These theories, though derived in some measure from different sources of mineralogical study, coincide not merely in their general outline, but in all their more prominent parts, and only differ in their mode of accounting for the more limited or local deposites.

M. Werner, "from whom alone," to adopt the language of M. de Cuvier, "we can date the commencement of real geology," so far as respects the mineral natures of the strata, divided in his first view of the subject, all the various rocks that enter into the solid crust of the earth, into FIVE classes.

Of these the FIRST CLASS consists of those rocks which, if we were to suppose each layer to be extended over the whole earth, would lie lowest, or nearest the centre, and be covered by all the rest; it comprises seven distinct sets, as granite, gneiss, mica-slate, clay-slate, a peculiar kind of porphyry, sienite, and a peculiar kind of serpentine. Of these granite lies the undermost, and sienite the uppermost; and in the midst of several of them we meet with beds of not less than eight other kinds of rock, as though dropped into them by accident—as topaz, another kind of porphyry, serpentine, limestone, flint-slate, and trap, quartz, and gypsum; which are hence called subordinate rocks of this class, and which extend the whole number of sets belonging to it to fifteen.

These are supposed to have been earliest produced, and when the earth first emerged from a state of chaos to a state of order; and are hence denominated PRIMITIVE FORMATIONS. They are distinguished by the following character. Not a single relic of either animal or vegetable petrifaction is to be found in any of them. The lowermost or older contain no carbonaceous matter; which is discoverable but very sparingly in the superior or newer. They are all chemical combinations, and generally crystallized; the crystallized appearance being most perfect in the oldest, and gradually becoming less perfect in the newer formations. I have already observed that the whole of this scale of formations does not regularly coat the nucleus of the earth; so little so, indeed, that sometimes even the granite itself, the lowermost rock of all, is left bare, and not pressed down or coated by a deposite of any other kind of rock: and so of the rest. Wherever this deficiency takes place, the rock thus left at liberty rises uniformly higher than it is found to do where pressed upon and invested with its common coatings. But every rock does

not, under such circumstances, rise equally high, or with an equal degree of freedom; for granite rises highest of all; and hence we frequently find it composing the tops of our loftiest chains of mountains, as well as the basis of the earth's solid crust. It forms the great body of the Swiss mountains and the Alps, though gneiss is here also found in great abundance.

The level of gneiss, when left at equal liberty, is a little lower than that of granite. It constitutes the vast mass of the Carpathian mountains, that divide Transylvania and Hungary from Poland.

The level of mica-slate is lower than that of gneiss, and the level of clay-slate lowest of all. So that there is a regular sinking of these respective levels from granite to clay-slate: while the newer porphyry and sienite are often laid over their summits, as though these two formations had been deposited long after the production of the others; an idea which is still farther strengthened by our meeting occasionally with a bed of breccia, or pudding-stone, composed of fragments of the older or lower rocks, capping the gneiss, granite, or other formation before the porphyry or sienite has been deposited.

The SECOND CLASS of rocks, or that which, when the number of coatings is complete, lies immediately over the preceding, consists of gray-wacke slate, and a peculiar kind of limestone, greenstone, and amygdaloid; together with subordinate masses of the proper primitive formations, sienite, porphyry, and granite; as though some portions of these had become crystallized after the rest, along with the next layers in succession, or had been separated from the parent rocks by some early commotion. Gray-wacke, which is a concrete term, denoting a conglomerate rock of a peculiar kind, having a basis of clay-slate, and being studded or otherwise intersected with portions of quartz, felspar, and scales of mica, may be exemplified by what in Cornwall is called *killas*, a far more euphonous word; and hence gray-wacke and gray-wacke slate may be distinguished by the terms *amorphose* and *schistose* killas. The Cornish killas lies directly over the granite of that county, which possesses the character ascribed by Werner to granite of the highest antiquity.*

These formations, for the most part, irregularly alternate with each other, instead of preserving one regular and successive order, as the different sets of the primitive formations do; excepting that the limestone appears usually undermost, and placed, as the basis of the rest, upon the sienite or uppermost of the first class. It is in this second class of formations that petrifactions first make their appearance; and it deserves particular attention that they are uniformly confined, both in the animal and vegetable kingdoms, to those of the lowest links in the scale of organization; and even among these to species which are at present altogether unknown, and which appear therefore to be totally extinct. Thus the animal petrifactions consist entirely of ammonites, mytilites, unknown corals, and other zoophytic worms; and the vegetable petrifactions of reeds, ferns, and other palm-like plants, mosses, and other cryptogamic productions, which occupy the lowest part in the scale of vegetable life, as zoophytic worms do among animals. It is here, also, that carbonaceous matter, which is chiefly of vegetable origin, first makes its appearance in any considerable quantity.

To this class of rocks, therefore, M. Werner has given the name of TRANSITION FORMATIONS; as believing them to have been produced while the earth was in a state of transition from inorganic matter to organic life,—from an uninhabited to an inhabited condition. The date of their formation, however, is proved even from their natural appearance, to have been very remote; since, as already observed, the whole of the petrifactions which they contain consist of plants and animals, not only of the very lowest species, but which now seem to be altogether extinct.

The THIRD CLASS of rocks is denominated FLOETZ, that is, FLAT OR HORIZONTAL FORMATIONS, in consequence of their usually appearing in beds much more nearly horizontal than the preceding. They lie immediately over the transition-class, and consist of the twelve following distinct sets of rock, each

* See Allan's remarks on the transition-rocks of Werner, in Thomson's Annals of Philos. vol. iii. p. 23 Compare with Jameson's definition of the same. Id. Feb. 1817, p. 17.

of which is generally found in a particular situation: sandstone of different kinds, and differently arranged, three sets; limestone, three sets; gypsum, two sets; calamine; chalk; coal; trap. The trap usually covers the whole of this class, as the newer porphyry and sienite cover the primitive formations: the relative position of the rest is more variable. The floetz or horizontal class is characterized by its containing an abundance of petrifactions in every one of its sets, and these of known animal and vegetable kinds; though still, of those that occupy the lower parts of the scale, as shells, fishes, the fishes much mutilated, a few tortoises, ferns, pines, and reeds; indicating that they were formed at a period in which organized beings of this character abounded, but in which those of other characters did not exist, or but rarely.

The FOURTH CLASS of formations, under the Wernerian system, is denominated ALLUVIAL, and constitutes the great mass of the actual surface of the earth's solid crust. They have been evidently produced by the gradual action of rain, river-water, air, and the elastic gases, upon the other classes, and may, comparatively, be considered as very recent formations, or rather as deposites, whose formations are still proceeding. They may be divided into two kinds; those deposited in the valleys of mountainous districts, or those elevated plains which often occur in mountains, and those deposited upon flat land.

The first kind consists of sand, gravel, and similar materials, which constituted part of the neighbouring mountains in their original state, and which remain, notwithstanding that these less durable parts have been thus washed or blown away. They sometimes contain ores, which also existed in the neighbouring mountains, and have been carried down by the agency of rain, air, or the elastic gases. The ores principally discovered in such situations are those of gold and tin; and these soils are often washed in order to separate them. Beds of loam are also occasionally met with on the plains of mountains, formed of the decomposed elements of animal and vegetable bodies that once occupied their sides.

The second kind of alluvial deposites, or that which occupies the flat land, consists of loam, clay, sand, marl, calcsinter, and calctuff, or stalactitic tufa, the basis of our common petrifactions; and which is found very largely in Sweden, Germany, and Italy, clothing with a calcareous coat the smaller branches of trees, leaves, prickles, moss, and other minute plants; eggs, birds, and birds' nests; preserving them from decay, by defending them from the action of the air. The clay and sand sometimes contain petrified wood; and in many parts are found the skeletons of quadrupeds, even of the largest magnitudes, as we shall have occasion to observe hereafter.* Here, also, occur earths and brown coal (in which is often traced mineral amber), wood-coal, bituminous wood, and bog iron ore.

The LAST, OR UPPERMOST, OF THE FIVE CLASSES of rocks of the Wernerian system, is denominated VOLCANIC FORMATIONS; and consists of two distinct sets, false and true.

The false comprise mineral substances which have experienced a change from the combustion of beds of coal situated in the neighbourhood: the chief minerals which are thus altered are porcelain, jasper, earth, slag, burnt-clay, columnar clay, ironstone, and, perhaps, polishing slate.

The real volcanic minerals are those which have been thrown out of the crater of a volcano, and consist of three kinds: first, those which, having been discharged frequently, have formed the crater itself of the mountain: secondly, those which have rolled down in a stream, and are known by the name of lavas: and, thirdly, the residual matter contained in the water which is often ejected, composed of ashes and other light substances, and which, when rendered solid by evaporation, is denominated volcanic tuff or tufa.

I have observed that these different classes of mineral formations are often traversed in various directions by other mineral substances which are called

* See series II. lect. ii. On zoological systems, and the distinctive characters of animals.

VEINS, as if the rocks they compose had split asunder in different places from top to bottom, and the chasms had been afterward filled up from other sources. These transverse lines or veins are worthy of notice in regard to their *shape* and the *substances* with which they are filled.

With respect to their *shape*, they appear to be almost always widest above, and gradually to diminish as they deepen, till at last they terminate in a point; exactly as if they had been originally fissures in the rock. Occasionally, indeed, they are observed to widen and contract alternately in different parts of their course; but this is by no means a common appearance.

Sometimes they are partially or altogether empty; and in this case they are real fissures, and are so denominated; but generally they are filled with matter more or less simple, and more or less different from the rock through which they pass. All the formations I have already noticed as existing in the shape of rocks have also been found in the shape of veins: whence we have veins of granite, porphyry, limestone, basalt, wacke, greenstone, quartz, clay, felspar, pit-coal, common salt, and metals of every kind. When the veins are compound, or consist of a variety of substances, these substances are almost always disposed in regular layers; one species of mineral constituting a central line or cylinder, and this being incrusted with a second mineral, and the second with a third, and in the same manner to the utmost sides of the veins. These layers are occasionally very numerous; that of the vein Georgius, at Freyburg, consists of not less than nine, and there is another in the same district, which, according to M. Werner extends to thirteen. It is not uncommon to find veins crossing each other in the same rock; and when this occurs, one of the veins may be traced passing through the other without any interruption, and completely cutting it in two, the cut vein always separating and vanishing at the point of intersection.

Nothing appears more obvious than that these veins must have been originally fissures produced by some unknown violence in the rocks in which they occur; and it is highly probable, as conjectured by M. Werner, that the mineral materials which constitute them have been deposited slowly from above during the formation of the different classes or sets of rock of which the different layers consist, while the rocks in which they occur were covered with water. Upon this theory veins are of course newer than the rocks in which they are met with, and which must have split to have produced them: and where two veins cross each other, that is obviously the newest that traverses the adjoining without interruption, as the fissures constituting the second vein must have been formed after the first was filled up.

The FIVE classes of rock formations we have thus far considered are those which entered into Professor Werner's system, as it first made its appearance. They are supposed to exist over the globe generally, and to be independent of chorographic or typographic changes, and have hence been still farther denominated UNIVERSAL FORMATIONS.

M. Werner has since, however, been induced to add to these a SIXTH class, consisting of what he has called PARTIAL OR LOCAL FORMATIONS: comprising those which are so often found in vast hollows or basins of particular countries; the materials of which are, in many instances, strangely intermixed, and have probably been carried down into such basins by circumscribed deluges, produced by an exundation of rivers or seas, occasionally alternating with each other, or by other partial disruptions. We have here, therefore, reason to expect,—what in fact is perpetually met with,—a motley combination of whatever substances may have existed in the course of such seas or rivers or rifted soils, with masses or fragments of most of the UNIVERSAL FORMATIONS, alternate beds of marine, and fresh water alluvions, and, consequently, animal and vegetable remains of all kinds.

The composite rocks that fill up the great basin around Paris, in which the skeletons of so many unknown animals, even quadrupeds of the hugest size, elephants, hippopotami, tapirs, mammoths, and other pachydermatous, or thick-skinned monsters, have been discovered, are of this LOCAL FORMATION. The celebrated quarries of Æningen, on the Rhine, are of a like kind; and

these, having been erroneously regarded of the same antiquity as Werner's UNIVERSAL FORMATIONS, have been appealed to by various writers as affording proofs of the falsity of his theory.*

We have other instances of this *local* formation in many parts of our own country, and particularly near the banks of the Thames. Mr. Trimmer has given an interesting account of the substrate of two fields in the vicinity of Brentford, that are loaded with the organic remains of the larger kinds of quadrupeds; as bones of elephants, approaching to both the Asiatic and the African species; horns of deer, apparently as enormous as those dug up in Ireland; bones of the bos genus; and teeth and bones of the hippopotamus; the last very abundant, and intermixed with fresh water shells,† and other fresh water relics.

Occasionally, however, marine remains are found intermingled with such animal fossils and composing their beds instead of those of fresh water; and not unfrequently layers of the one kind, as in the basin of Paris, are irregularly surmounted by layers of the other. But no human skeletons are discovered in the midst of any of these rocks, although the bones of man are as capable of preservation as those of any other animal: the only known instance of this sort being that imported into our own country from Guadaloupe by Sir Alexander Cochrane, and which is now exhibited in the British Museum, imbedded in a block of calcareous stone; a very accurate description of which has been published in the Philosophical Transactions by Mr. König.

It is hence obvious, that the catastrophes which involved these enormous quadrupeds in destruction must have occurred at a period when mankind had no existence in the regions which are thus overwhelmed; and in some places overwhelmed alternately by disruptions and inundations of sea and of fresh water. And it is equally obvious, that as the fossil bones are not rolled or violently distorted, or deprived of their natural contour, such remains have not been brought to their present beds from a distance; but that the deluge must have been sudden, and overtaken them in their natural resorts; and hence may, in many cases, have swept away all the individuals of a species in a common calamity.

There is, however, a great difficulty with some naturalists in conceiving that such animals as the elephant, the tapir, the rhinoceros, the hippopotamus, the mammoth, or mastodon, animals now only found in the torrid regions, could have existed in these northern parts of the globe. M. de Marschall endeavoured by one sweeping stroke of the fancy to solve this, as well as that of the extraordinary fragments in which they are often imbedded, and held out that the whole have fallen at different times, like meteoric stones, from heaven.‡ The real difficulty, however, vanishes in a considerable degree, if not entirely, when we reflect, that although the torrid regions furnish us with some of these genera, they do not appear in any instance to contain the same precise species as are traced among the large fossil quadrupeds of the northern and colder parts: and hence it is no argument, that because the habits of the extant species do not qualify them for a residence in these latter regions, such situations might not have furnished a comfortable home to the species whose remains are found among us. The fossil species do not differ less from the living to which they make the nearest approach, than various animals that are familiar to us do from others that belong to the same tribes, and which are found, under one species or other, over the whole world. The race of horses, of swine, or of sheep, furnishes us with abundant examples of this remark: and that of dogs affords perhaps a still more striking illustration; for while under one form, that of the *isatis* or Arctic fox, the canis *Lagopus* of Linnæus, we find it in the northernmost coast of America, and even the frozen sea, living in clefts, or burrowing on the naked moun-

* For an admirable defence of this part of the theory, see Mr. Jameson's essay "On Formations," inserted in the Annals of Philos. No. iii. p. 191.

† Phil. Trans. for 1813. p. 135. See also Mr. Webster's valuable essay on the same subject, in vol. ii. of the Transactions of the Geological Society.

‡ Recherches sur l'Origine, &c. Geissen, 1802.

tains, and in that of the almost infinite varieties of the c. *familiaris* or domestic dog, in the bosom of our own country,—in the form of the c. *aureus*, chacal or jackal, we meet with it in the warmest parts of Asia and Barbary, prowling at night in flocks of one or two hundred individuals.

The extensive TURBARIES OR PEAT-FIELDS, which are so common to many parts of Europe, are produced by an accumulation of the remains of sphagnum and other aquatic mosses. These surround and cover up the small knolls upon which they are formed; or, in many places, descend along the valleys after the manner of the glaciers of Switzerland; but, while the latter melt away every year at their lower edges, the mosses are not checked by any obstacle in their regular increase; and as such increase takes place in determinate proportions, by sounding their depth to the solid ground we may form some estimate of their antiquity.

The ordinary rise of those extensive ranges of DOWNS which are seen skirting the coasts of many countries, and especially where the shore is not very bold, is a mixed effort of sea and wind. To produce this, however, the soil that the sea washes over must consist of sand. This is first pushed in successive tides towards the shore; it next becomes dry, by being left there at every reflux of the sea; and is then drifted up the beach, and to a considerable distance from the beach, by the winds which are almost always blowing from the sea, and often in whirls or eddies; and are at length fixed by the growth of wild plants, whose seeds are in like manner wafted about on the wings of the breeze, or casually dropped with the excretions of birds or other animals that pass over them. In several parts, observes M. Cuvier, these proceed with a frightful rapidity, overwhelming forests, houses, and cultivated fields in their irresistible progress. Those on the coast of the Bay of Biscay have actually buried a considerable number of villages whose existence is noticed in the records of the middle ages. And even in the present day they are threatening not fewer than ten distinct hamlets with almost inevitable destruction: one of which, named Mimigan, has been in perpetual danger for upwards of twenty years, from a sand-hill of more than sixty feet in perpendicular height, produced by the cause we are now contemplating, and which is very obviously augmenting.*

There are various forelands on the coasts of the North Sea, and particularly on those of the counties of Sleswigh and Holstein, which are formed in the same manner.† But the most extraordinary inroads of sand storms and sand floods are, perhaps, those which have taken place in the Libyan Desert and in Lower Egypt. M. Denon informs us, in his travels over this part of the world, that the summits of the ruins of ancient cities buried under mountains of drifted sands still appear externally; and that but for a ridge of mountains, called the Libyan Chain, which borders the left bank of the Nile, and forms 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," says M. Denon, "can be more melancholy, than to walk over villages swallowed by the sand of the desert, to trample under foot the roofs of their houses, to strike against the tops of their minarets, and to reflect, that yonder, in days of yore, were cultivated fields, that hard by were groves of flourishing trees, and the dwellings of men close at hand;—and that all has now vanished."‡

The various ISLANDS that spot the surface of the sea have arisen from different causes. Many of them have been merely separated from the adjoining continent by the inroad of the sea itself upon the mainland; others have been thrown up by volcanoes, which have at times disgorged prodigious blocks of granite among the mixed materials, such as are frequently found in the Danish archipelago, in the midst of the *geest*, or alluvial matter, which has collected around them. Other islands are altogether the masonry of madre-

* Report concerning the downs of the Gulf of Gascony, or Bay of Biscay, by M. Tassin, Mont de Marsan. an. x. Cuvier, Theory of the Earth, § 31.

† De Luc, Voyages Géologiques, tom. i.

‡ Jameson's Notes on Cuvier's Theory, &c. p. 217. Compare Dolomieu's Memoir on Egypt, in Journ. de Physique, tom. xlii.

pores, and other coral zoophytes of wonderful industry and perseverance, of which the South Sea furnishes us with the largest and most astonishing specimens. These islands are for the most part flat and low, and surrounded by enormous belts of coral reefs. Most of the calcareous zoophytes are employed in their construction, but the principal worm is the madrepora *lubricata* of Linnæus.

In so large an abundance, and with so much facility, is calcareous matter elaborated by these, as well as by various other animals, and especially the testaceous worms, that M. Cuvier is inclined to ascribe all the calcareous rocks that enter into the solid crust of the earth to an animal origin.* But this is to suppose the earth of a far higher antiquity, and to have been the subject of more numerous general deluges, and inversions of sea and land, than are called for by the Wernerian system, or appear reconcileable with the Mosaic narrative. M. Cuvier apprehends, indeed, that such catastrophes may have occurred five or six times in succession, at a distance of four, five, or six thousand years from each other; and that even the chalk formation found in the basin of Paris originated in a revolution of this kind that occurred antecedently to that which is usually regarded as the flood of Noah. And, following up this idea, he conceives, towards the close of his Introductory Theory of the Earth, that if the science of fossil organic productions could be carried to a much higher degree of perfection, we should be able to obtain far fuller information upon this subject; "and man, to whom only a short space of time is allotted upon the earth, would have the glory of restoring *the history of thousands of ages which preceded the existence of the human race*, and of thousands of animals that never were contemporaneous with his species."

LECTURE VII.

ON GEOLOGY.

(The subject continued.)

IN our last study I attempted a brief sketch of the chief phenomena that occur to the eye of the geologist upon a survey of the solid crust of the earth, as far as he is able to penetrate into it. The conclusion to which such phenomena lead us is the following: that the rudimental materials of the globe, to the utmost depths we are able to trace them, existed at its earliest period, in one confused and liquid mass; that they were afterward separated, and arranged by a progressive series of operations, and a uniform system of laws, the more obvious of which appear to be those of gravity and crystallization; and that they have since been convulsed and dislocated by some dreadful commotion and inundation that have extended to every region, and again thrown a great part of the organic and inorganic creation into a promiscuous jumble.

Now, the only two causes that can enter into the mind of man as being competent to the fluidity that apppears at first to have existed throughout the whole crust of the earth are FIRE, or a peculiar SOLVENT. But, if a solvent, that solvent must have been WATER: for there is no other liquid in nature in sufficient abundance to act the part of a solvent upon a scale so extensive.

And hence our inquiries into this subject become in some degree limited, and are chiefly confined to what have been called the PLUTONIC and the NEPTUNIAN hypotheses; the origin of the world in its present state from igneous fusion, and from aqueous solution. Both these theories are of very early

* Some writers have proceeded much farther than this, for they have resolved all the solid materials of the earth's crust into an organic origin. Such was the opinion of Demaillet and Lamarck, who suppose that every thing was originally fluid; that this universal fluid gave rise to plants and animals; that all clay or argillaceous earth is the produce of the former; all calcareous earth of the latter; and that siliceous earth has been the result of the two. Telliamid, p. 169. Philosophie Zoologique, *passim*.